

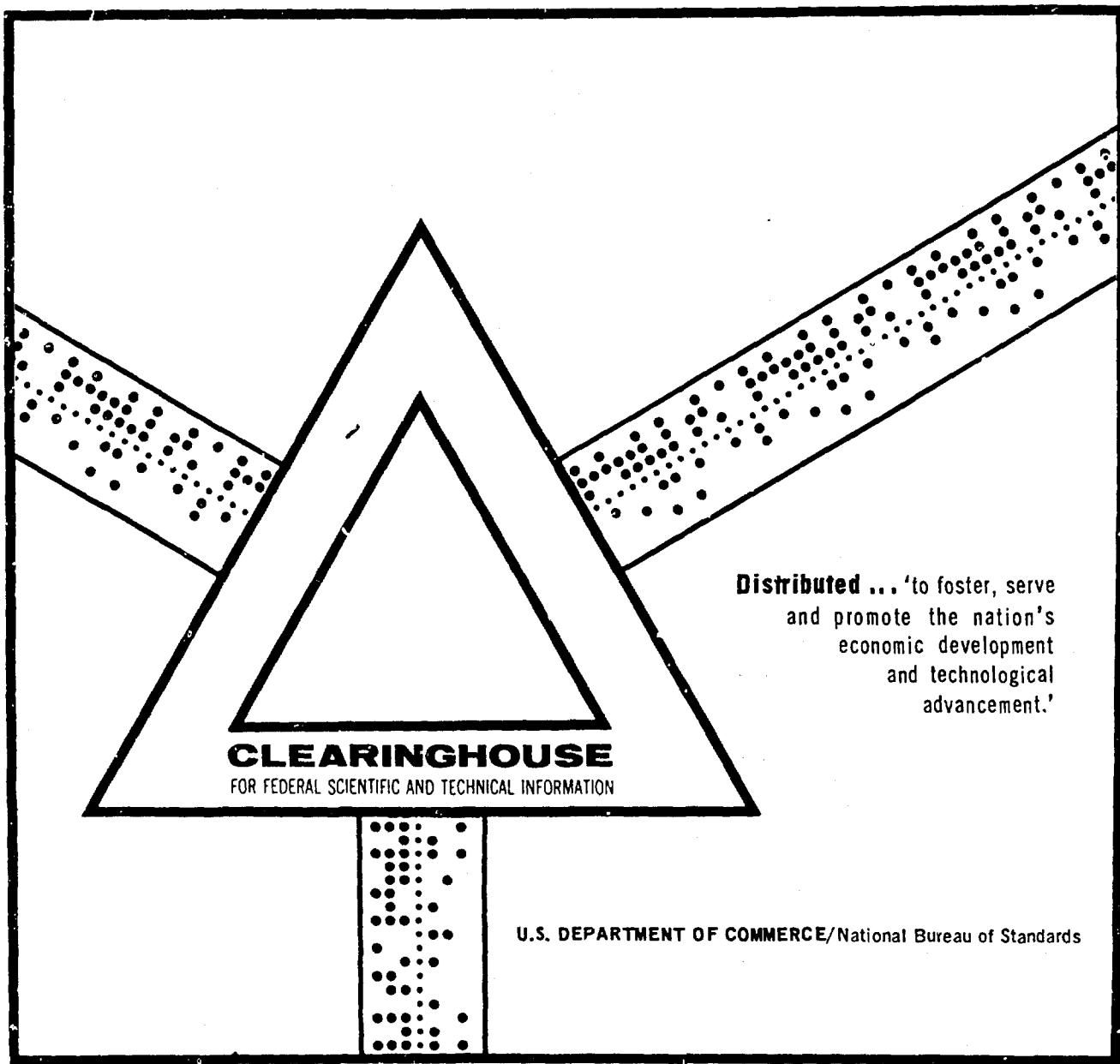
AD 697 794

ANNUAL REPORT (5TH) OF THE AIR FORCE
MACHINABILITY DATA CENTER

John Maranchik, Jr.

Air Force Machinability Data Center
Cincinnati, Ohio

October 1969



This document has been approved for public release and sale.

AD 697794

Reproduced by the
CLEARINGHOUSE
for Federal Scientific & Technical
Information Springfield Va. 22151

AD 697 794

**FIFTH ANNUAL REPORT OF THE
AIR FORCE MACHINABILITY DATA CENTER**

John Maranchik, Jr.
Metcut Research Associates Inc.

OCTOBER 1969

Air Force Materials Laboratory
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

FOREWORD

The Fifth Annual Report of the Air Force Machinability Data Center (AFMDC) covers work performed under Contract F33615-69-C-1112 from October 1, 1968 through July 31, 1969. The work described in this report covers that accomplished under project no. SM 810/8975. It also cites statistics covering the 4-3/4 years' that AFMDC has been in operation. This Center is operated for the Air Force Materials Laboratory, by Metcut Research Associates Inc., 3980 Rosslyn Drive, Cincinnati, Ohio 45209. The manuscript was released by the author, John Maranchik, Jr., Director of AFMDC, in October 1969 for publication as an AFMDC Report.

This effort is being administered under the direction of the Air Force Materials Laboratory, Wright-Patterson Air Force Base, with Mr. E. L. Horne (MAAM) as project engineer.

The author wishes to acknowledge the contribution by Mrs. Charlotte Crockett who assisted in the preparation of this publication.

Your comments are solicited on the potential utilization of the Air Force Machinability Data Center as applied to your present or future production programs.

This report has been reviewed and is approved.



Edward Dugger
Chief, Materials Information Branch
Materials Support Division
Air Force Materials Laboratory

ABSTRACT

FIFTH ANNUAL REPORT OF THE
AIR FORCE MACHINABILITY DATA CENTER

John Maranchik, Jr.

This is the Fifth Annual Report of the Air Force Machinability Data Center covering period October 1, 1968 through July 31, 1969 (Contract F33615-69-C-1112). Three thousand and seven hundred and eighty (3,780) documents were processed from which 33,868 cards were key punched. Currently, there are 19,721 evaluated documents and 149,951 punched cards in AFMDC files. One thousand and one hundred and forty one (1,141) specific inquiries were answered for 520 different organizations, representing 753 individuals in 106 different SIC categories in this 10-month period. The average number of inquiries was 114 per month. Since the Center's operation began in October 1964 a total of 4,456 specific inquiries have been processed.

The average cost of inquiries equaled \$55.19 per inquiry.

The data acquisition plant visit program was continued and since late 1966, 56 visitations have been made, primarily to aerospace firms.

Statistics are presented on cost savings by AFMDC Users. Through July 31, 1969 it has been estimated, very conservatively, that these savings amount to \$45,093,500.00.

A summary is presented of AFMDC's proposed output recovery cost plans.

Work continued on investigating relationships between machining variables and work materials.

This abstract has been approved for public release and sale; its distribution is unlimited.

PREFACE

This report covers a 10-month period of operation from October 1, 1968 through July 31, 1969. It is presented primarily in the form of individual charts which are self explanatory with regard to organization of the Center and the results of its efforts, including costs. For each individual chart, the Appendix provides some further comments concerning various aspects of AFMDC during its fifth year of operation.

For a complete analysis of the progress made by the Center from its early inception to the present, the following five references should be reviewed:

“Final Report on the Design of a System for Collecting, Evaluating and Disseminating Machinability Data for Aerospace Materials”, Technical Documentary Report Nr. ASD-TDR-63-572, July 1963, AD-416743.

“First Annual Report of the Air Force Machinability Data Center”, AFMDC 65-2, February 1966, AD-482278.

“Second Annual Report of the Air Force Machinability Data Center”, AFMDC 66-4, February 1967, AD-813037.

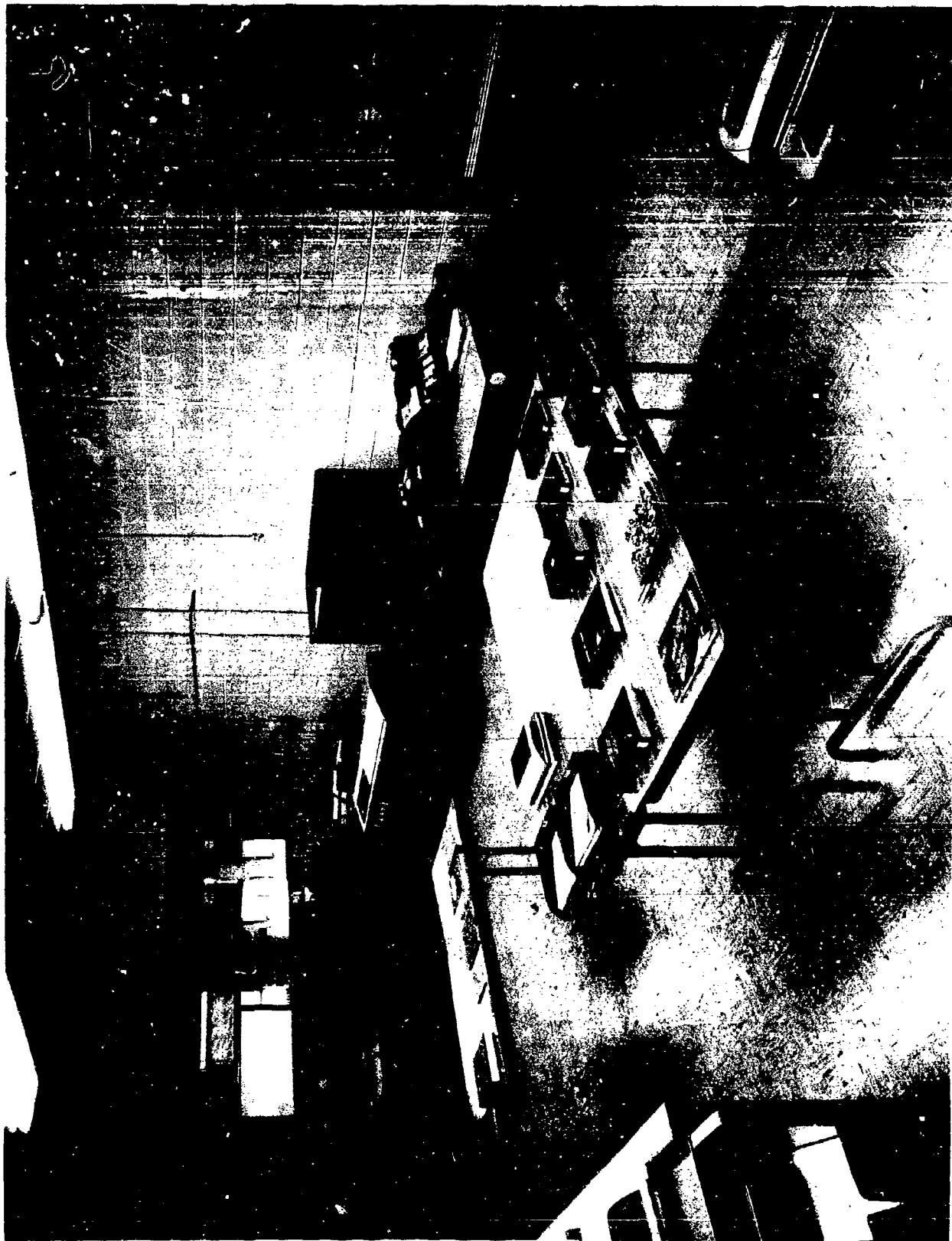
“Third Annual Report of the Air Force Machinability Data Center”, AFMDC 67-8, February 1968, AD-829879.

“Fourth Annual Report of the Air Force Machinability Data Center”, AFMDC 68-6, October 1968, AD-844920.

TABLE OF CONTENTS

	<u>Page</u>	<u>Appendix</u>
AFMDC ORGANIZATION		
Description of AFMDC	1	A-1
AFMDC Organization Chart, Figure 1	2	A-1
AFMDC Operational Areas	3	A-2
AFMDC Operations Chart, Figure 2	4	A-2
AFMDC USER FILE		
AFMDC User File Map, Figure 3	5	A-4
Distribution of AFMDC User File.	6	A-4
IBM 1130 COMPUTER - DATA PROCESSING		
Data Code Forms for Final Technical Evaluation, Figure 4	7	A-6
Flow Chart for Fortran Program to Store, Add to, Search Inquiry File, Figure 5.	8	A-7
Output of Inquiry File Search, Figure 6.	9	A-8
Output of Uniterm File Search, Figure 7.	10	A-9
Output of Final Technical Evaluated Data, Figure 8	11	A-9
Computer Printout of a Selective Search on Surface Integrity File, Figure 9.	12	A-9
Formulae Used in Determining Cost Per Piece in Face Milling and End Milling, Figure 10	13	A-10
Cost and Production Rate for Milling, Figure 11.	14	A-10
Computer Printout for Investigating Relationships Between Machining Variables, Figure 12.	15	A-10
SUMMARY OF SPECIFIC INQUIRIES		
Inquiry Processing Flow Chart, Figure 13	16	A-10
Typical Inquiry Input and Response, Figure 14.	17	A-10
Summary of Specific Inquiries by Type of Inquiry, Figure 15.	18	A-11
Analysis of Inquiries by State, Figure 16	20	A-11
General Analysis of Inquiries, Figure 17	21	A-12
Analysis of Inquiries by Material Group, Figure 17	21	A-12
Analysis of Inquiries by Type of Machining Operation, Figure 18.	22	A-12
Analysis of Uniterm Type Inquiries, Figure 19.	23	A-12
Summary of Specific Inquiries by SIC Number, Figure 20	24	A-13
Government Agencies and Services Supported Directly or Indirectly by AFMDC Inquiries, Figure 21	26	A-13
Summary of Inquiries Processed by AFMDC for STSP and SBA, Figure 22.	27	A-13
Companies and Agencies Submitting Inquiries to AFMDC, Figure 23.	28	A-14
Summary of Specific Inquiries by Companies Making 5 or More Requests, Figure 24.	40	A-14
DATA PRODUCTS		
Photograph of AFMDC Data Products, Figure 25	42	A-15
Photograph of AFMDC Titanium Booklet, Figure 26.	43	A-15
Typical Formats for Data Presentation, Figure 27	44	A-15
Description and Distribution of AFMDC Data Products, Figure 28	45	A-15
DATA ACQUISITION		
Data Acquisition Plant Visit Program	46	A-16
AFMDC COST AND FUTURE PLANNING		
Code Sheet for Project Time Card, Figure 29.	47	A-16
AFMDC Daily Time Slip, Figure 30	49	A-16
Computer Printout of AFMDC Project Time Cards, Figure 31	50	A-16
AFMDC Operating Costs, Figure 32	51	A-16
AFMDC Input and Output Summary, Figure 33.	52	A-16
Economic Environment for AFMDC Operations, Figure 34	54	A-17
Potential for AFMDC Services to Industry, Figure 35.	55	A-18
Cost Savings Resulting From AFMDC Operation, Figure 36	56	A-18
AFMDC Plans For Recovery of Output Costs, Figure 37.	57	A-20
Future Planning	58	A-21

PHOTOGRAPH OF AFMDC



To: Recipients of AFMDC's Fifth Annual Report

Correspondence concerning this Fifth Annual Report should be sent to Mr. Robert E. Snider, the new Director of the Air Force Machinability Data Center (AFMDC). On November 20, 1969, Metcut Research Associates Inc. accepted the resignation of Mr. John Maranchik, Jr., as Director of AFMDC and as an employee of Metcut.

Mr. Snider has had 37 years of experience in the field of machining and manufacturing, including 13 years at North American/Columbus in manufacturing engineering and supervision. He has served as a machining data analyst and supervisor of technical inquiries since coming to AFMDC in 1964. In August of this year, he was appointed Assistant Director. His various duties at the Center have given him a good insight into the problems of information technology, particularly those relating to material removal.

Mr. Snider will report to Dr. John F. Kahles, Vice President and Director of Information Technology. Dr. Kahles developed the machining data center concept at Metcut, directed the design study leading to the establishment of AFMDC, and served as its first Director.

AFMDC's pioneering in machining information services has attracted worldwide attention and has already stimulated design studies for machining data centers in countries such as England, Germany and Japan. Under Mr. Snider's direction, we expect to continue our close working relationships with the material removal industry in the United States and even to enhance the scope of our services currently being funded by the Materials Information Branch of the Air Force Materials Laboratory under Contract F33615-69-C-1112.

Michael Field, President
Metcut Research Associates Inc.

November 1969

DESCRIPTION OF AFMDC

AIR FORCE MACHINABILITY DATA CENTER, 3980 Rosslyn Drive, Cincinnati, Ohio 45208.
Operated for the Air Force Materials Laboratory, Materials Support Division, under
Contract F33615-69-C-1112, by Metcut Research Associates Inc.

SCOPE

The Air Force Machinability Data Center (AFMDC) collects, evaluates, stores, and disseminates material removal information including specific and detailed machining data for the benefit of industry and government. Strong emphasis is given to engineering evaluation for the purpose of developing optimized material removal parameters, such as speeds, feeds, depths of cut, tool material and geometry, cutting fluids and other significant variables. Data are being processed for all types of materials and for all kinds of material removal operations such as turning, milling, drilling, tapping, grinding, electrical discharge machining, electrochemical machining, etc.

COLLECTION

AFMDC has a mechanized system in which punch cards are used to store and retrieve all types of material removal information including all significant numerical data. An IBM 1130 computing system is being used for storing and processing data from a master card and disk file and for computer decoding. The focal concept for acquisition, interrogation, or presentation of information is the specific material (with definite chemical, physical, or mechanical properties) and the specific material removal operation being used. When necessary, card source control codes may be used to retrieve original documents which are in document storage at AFMDC.

INFORMATION SERVICES

AFMDC places strong emphasis on providing specific and detailed answers to technical inquiries in the field of material removal. A User File, consisting of important users in the field of material removal, has been developed to receive information products including machining data pamphlets and tables on materials of current interest, state-of-the-art reports, technical announcements, and other appropriate items. Services are available without charge to the aerospace industry, Department of Defense (including all of the military services and their contractors), and other government agencies, technical institutions, and non-military industries in a position to assist the defense effort.

TO REQUEST MACHINING INFORMATION

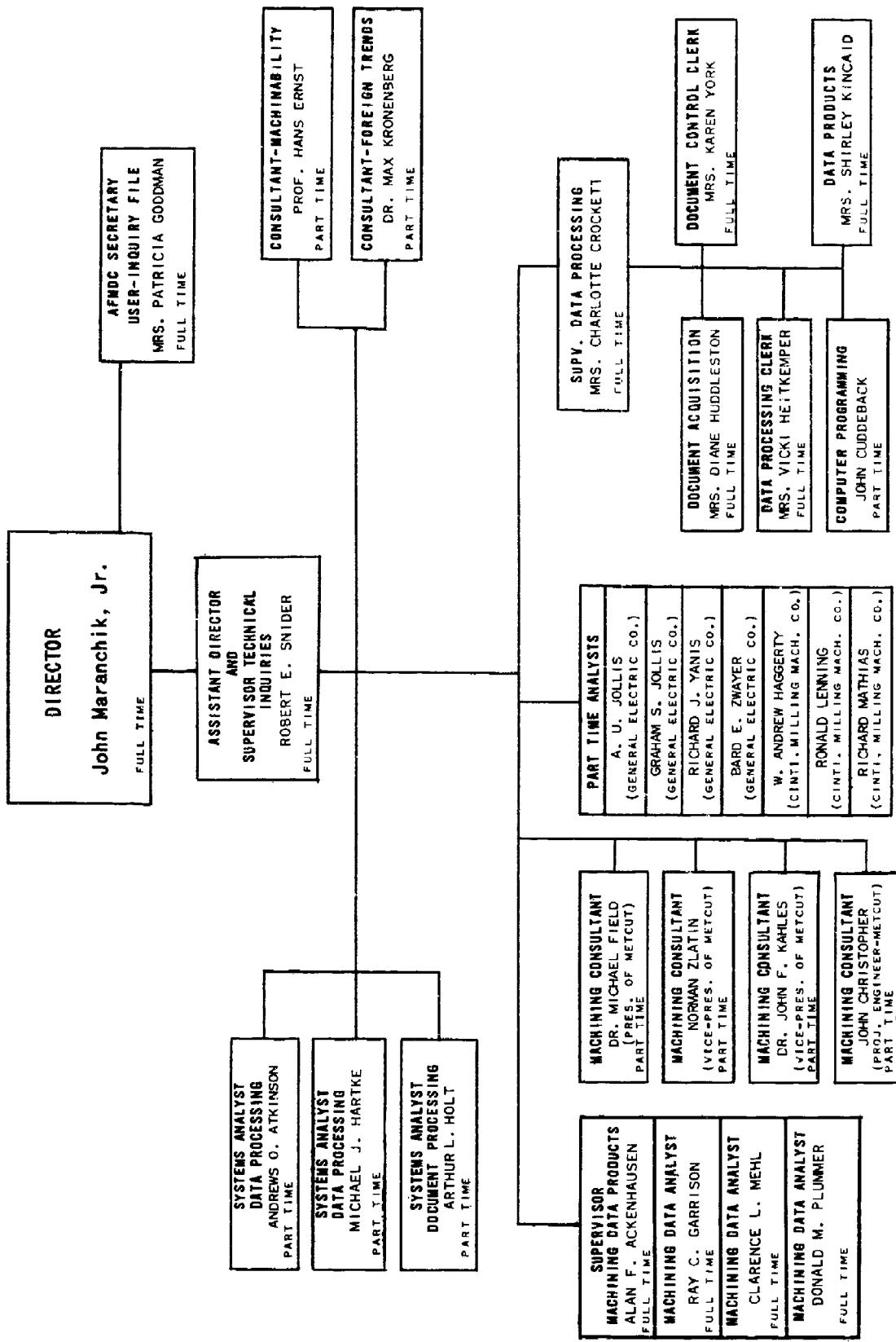
Telephone: 513-271-8510
TWX: 810-481-2840 or
Write: Air Force Machinability Data Center
3980 Rosslyn Drive
Cincinnati, Ohio 45208

TO HELP US ANSWER YOUR INQUIRY, IF POSSIBLE PLEASE:

1. Identify the material being machined (specification or tradename); condition, (as cast, hot rolled, cold drawn, annealed, quenched and tempered, etc.); microstructure and hardness.
2. Identify the material removal operation in question (turning, milling, drilling, tapping, surface grinding, electrical discharge machining (EDM), electrochemical machining (ECM), etc.).
3. Specify reasons for requiring data unless your needs are proprietary. This enables AFMDC to broaden the scope of its technical advice.
4. Specify delivery requirements.
5. Indicate to whom the inquiry reply should be sent.
6. Transmit all details concerning present practices, including feeds, speeds, cutting tool material and geometry, cutting fluids, etc., in the event your inquiry pertains to improvement of an existing machining situation.

NOTE: Association of the names of companies and individuals with specific requests is kept confidential. However, data developed remain the property of AFMDC for dissemination as required for answering similar inquiries and for developing data products.

AFMDC ORGANIZATION CHART



SEE APPENDIX, PAGE A-1

FIGURE 1

AFMDC OPERATIONAL AREAS

At AFMDC, personnel shown in Figure 1, page 2, work in ten functional areas of operation. These are indicated below along with the numbers used for time coding purposes:

1	Administration	Administration of technical and general activities of AFMDC
2	Engineering Supervision	Technical activities including all mechanized handling of data and processing of inquiries
3	Systems Analysis	Design of the machinability data system, particularly processing
4	Machining Data Analysis	Technical evaluation of machinability data and information including Preliminary Screening
5	Data Processing	Operation of a mechanized system including a computer
6	Data Control	Superimposition and use of controls to guarantee proper operation of data processing system
7	Document Acquisition and Document Storage	Acquisition of all types of data and information for processing. Storage of documents including those which have received Final Technical Evaluation and those in process
8	Data Dissemination	Dissemination including duplication and printing
9	Machining Data Verification - Experimental Machining	Laboratory and shop work necessary for resolving highly significant and controversial data situations
0	Secretarial and Clerical	Development and execution of all procedures relating to typing and filing

AFMDC OPERATIONS CHART

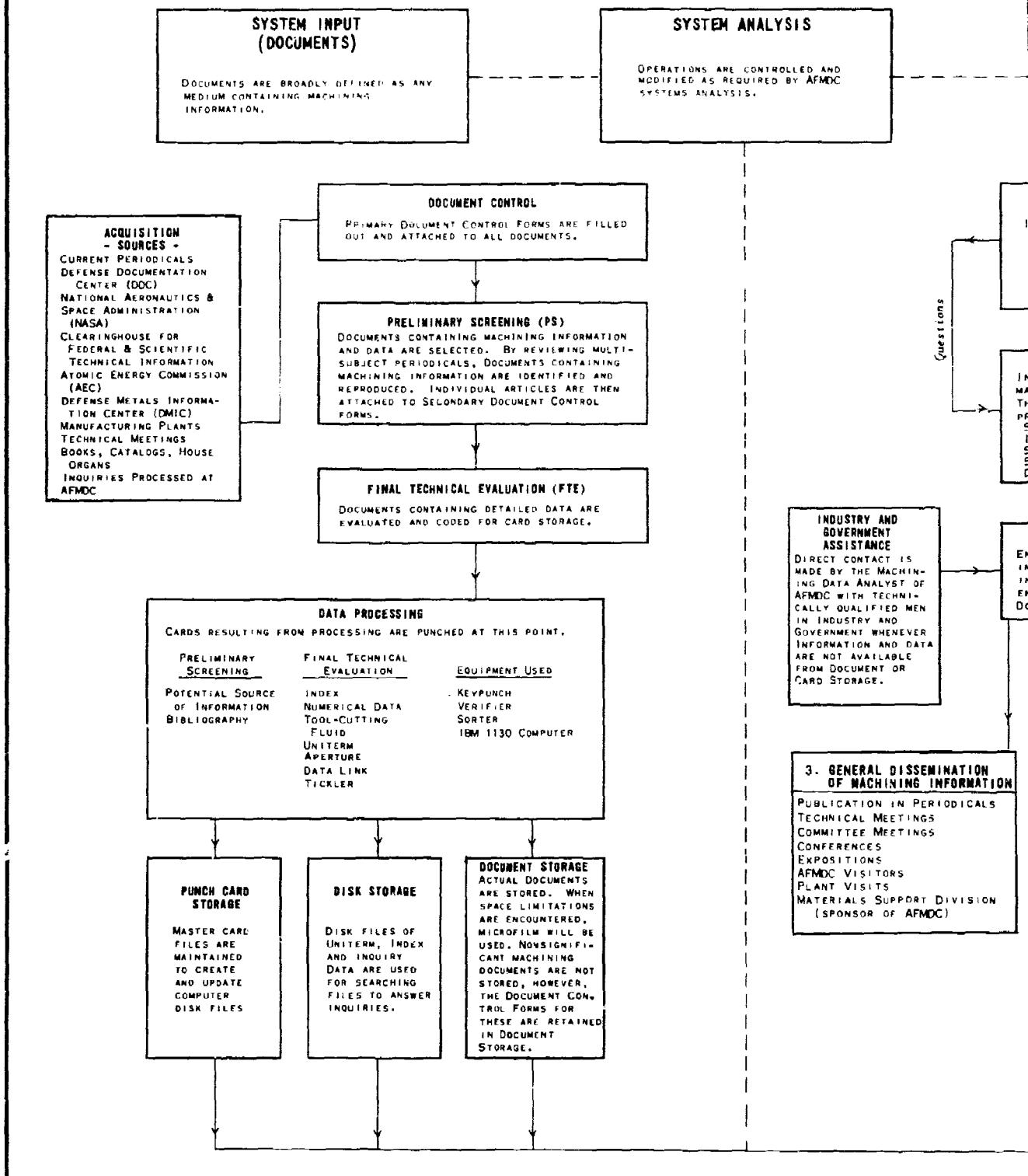
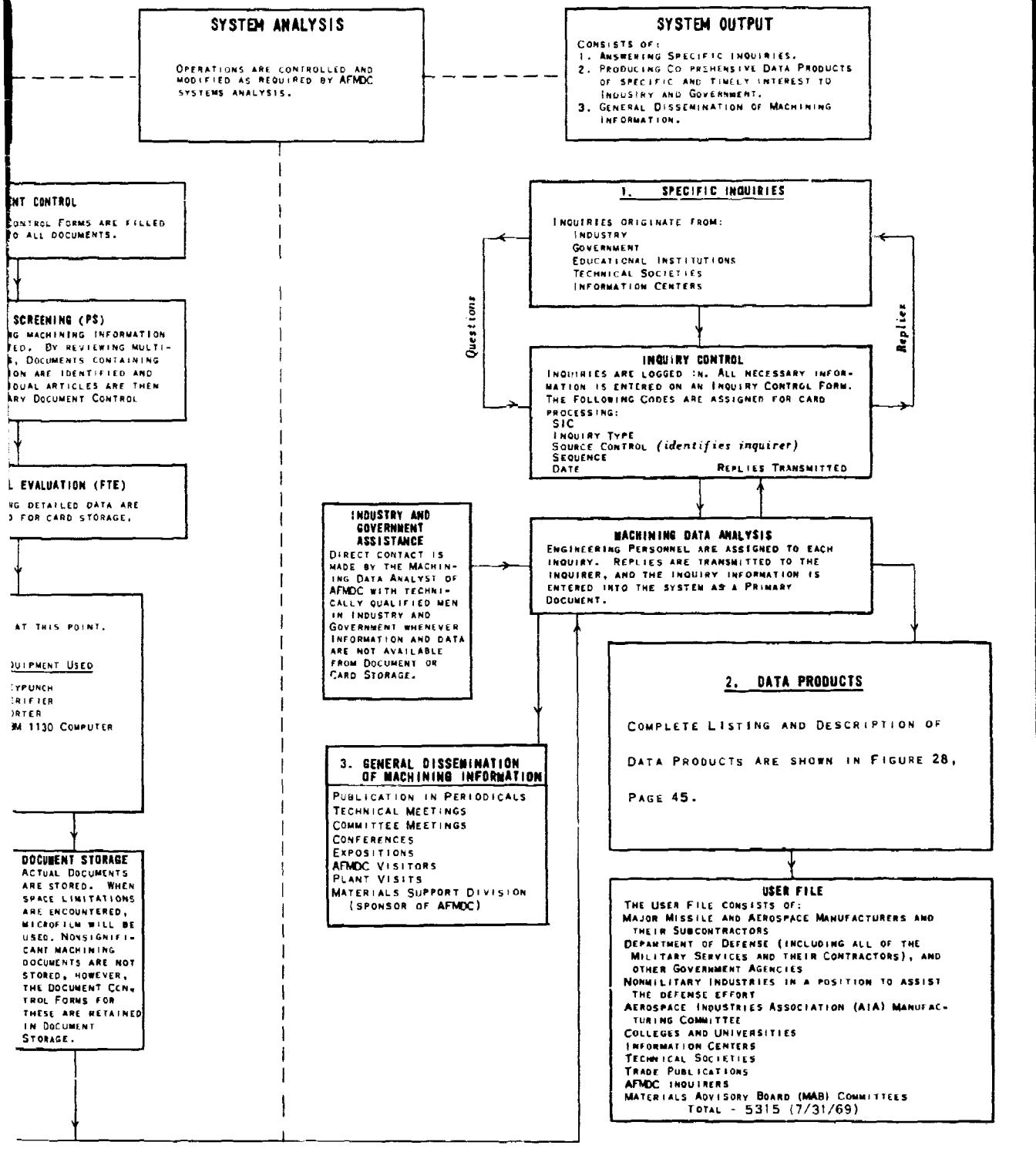


FIGURE 2

AFMDC OPERATIONS CHART



AFMDC USER FILE MAP

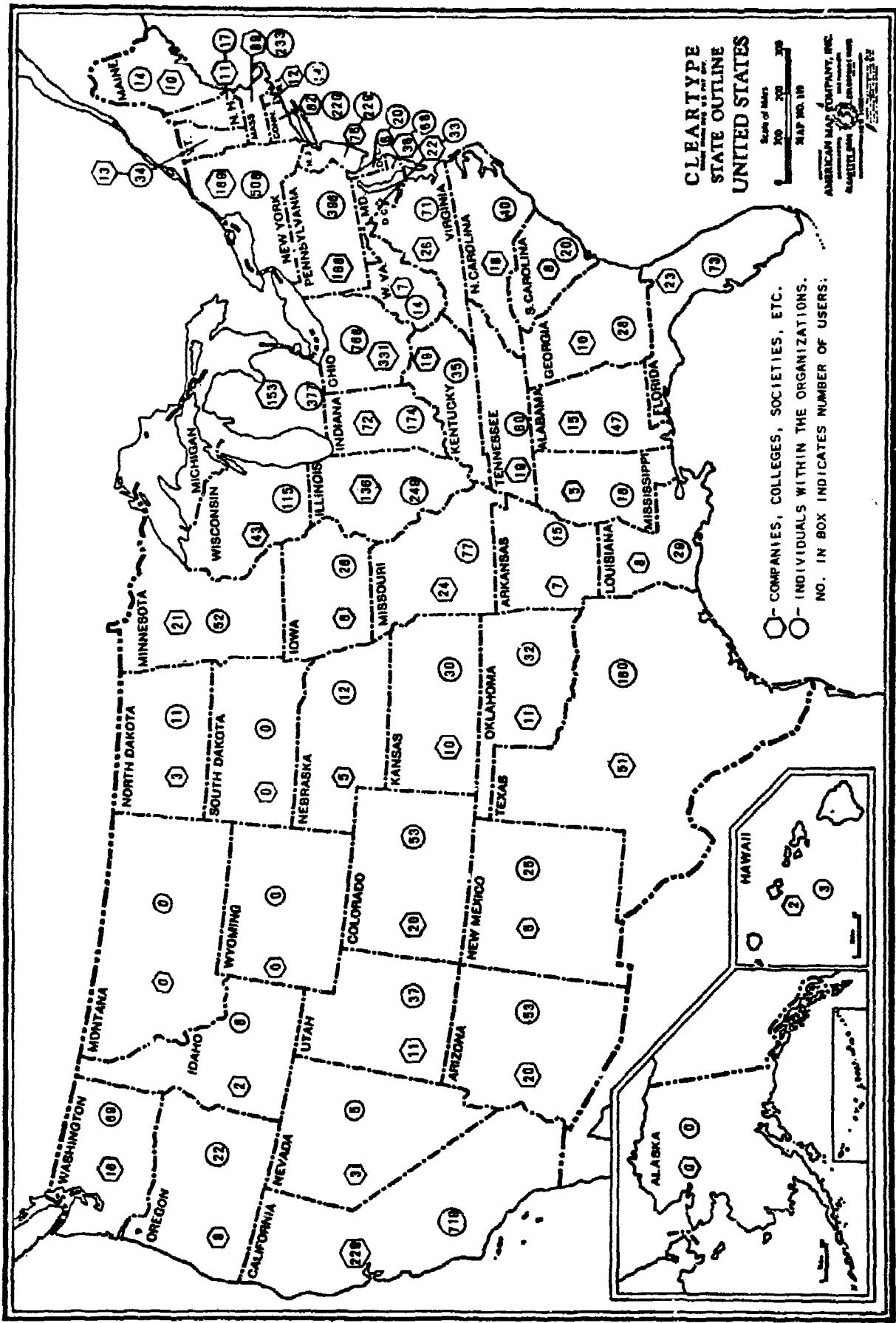


FIGURE 3

DISTRIBUTION OF AFMDC USER FILE

The basic User File was developed as indicated in Appendix, Page A-4. Names are added to the User File as a result of 1) inquirers, 2) visitors, 3) additional names submitted by current Users, 4) requests resulting from dissemination of data products, and 5) technical articles published in periodicals and announcements pertaining to the Center.

GENERAL CONCENTRATION OF USERS BY NUMBERS

STATES	ORGANIZATIONS	TOTAL NO. ORGANIZATIONS	STATES*	INDIVIDUAL	TOTAL INDIVIDUAL USERS
4	0	0	4	0	0
17	1-10	107	15	1-25	218
16	11-25	275	11	26-50	373
3	26-50	105	10	51-125	691
5	51-100	370	8	126-300	1,285
6	OVER-100	1,206	5	OVER-300	2,768

AREA CONCENTRATION OF ORGANIZATIONS

West Coast (3 states) - 253 companies
North Midwest (5 states) - 735 companies
Northeast (5 states) - 604 companies

These figures indicate that 77% of User companies lie in 25% of the United States.

The total User File (5,315), can be broken down as follows:

Company Users (Individuals)	4,335
Companies	1,742
College Users (Individuals)	790
Colleges	211
Societies, Centers, etc. (Individuals)	190
Societies, Centers, etc.	110

* Includes Washington, D.C.

DATA CODE FORMS FOR FINAL TECHNICAL EVALUATION

TOOL - CUTTING FLUID #													
TOOL STYLE	"BACK-RAKE"	"SIDE-RAKE"	END-RAKE	SIDE-REL.	"ECEA"	"SCEA"	HOSE RADIUS INCHES	CHIP-BREAKER WISTE-IN.	CHIP-BREAKER DEPTH-IN.	CHIP-BREAKER RESISTANCE	TOOL MATERIAL	CUTTING FLUID	SEE PAGE
1/4" 160° 1/2" 100° 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050	1/4" 160° 1/2" 100° 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050	1/4" 160° 1/2" 100° 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050	1/4" 160° 1/2" 100° 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050	1/4" 160° 1/2" 100° 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050	1/4" 160° 1/2" 100° 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050	1/4" 160° 1/2" 100° 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050	1/4" 160° 1/2" 100° 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050	1/4" 160° 1/2" 100° 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050	1/4" 160° 1/2" 100° 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050	1/4" 160° 1/2" 100° 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050	1/4" 160° 1/2" 100° 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050	1/4" 160° 1/2" 100° 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050	1/4" 160° 1/2" 100° 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050 0.050

COLUMN 1 (TYPE)

- 1 - SOLID
- 2 - BRAZED (INSET)
- 3 - THERMOSET

COLUMN 2 (RAKE OR INSET)

- 1 - HORIZONTAL
- 2 - V-RAKE
- 3 - TRIANGLE
- 4 - DIAGONAL
- 5 - DIAMOND
- 6 - DIAGONAL

COLUMN 3 (CHIPBREAKER TYPE)

- 1 - MECHANICAL
- 2 - DROPPING
- 3 - HOLE
- 4 - HOLLOW

COLUMN 4 & 5 (CHANCE SIZE OF HOLEDRILL OR TOOL, SIC)

IF TOOL, 15 ENDAGE CODE BY 1/16IN.
IF TOOL, 15 RESTURGE CODE BY 1/16IN. OR 0.0625 OR DEPTH
IF TOOL, 15 ROUND DRILLING CODE BY 1/16IN. OR 0.0625

ENDAGE - 15 = 15° + 1° SAWAGE
RECTANGLE - 15 = 0.075" X 0.075" + 0.075" X 1°
ROUND - 15 = 0.075" DIAMETER

COLUMN 6

- 1 - RIGHT HAND CUTTING
- 2 - LEFT HAND CUTTING
- 3 - HORIZONTAL
- 4 - DIAGONAL
- 5 - ROLLER TURNING
- 6 - PLATING
- 7 - DRAPING

* Circle appropriate plus or minus sign.

FIGURE 4

FLOWCHART FOR FORTRAN PROGRAM TO STORE, ADD TO, OR SEARCH

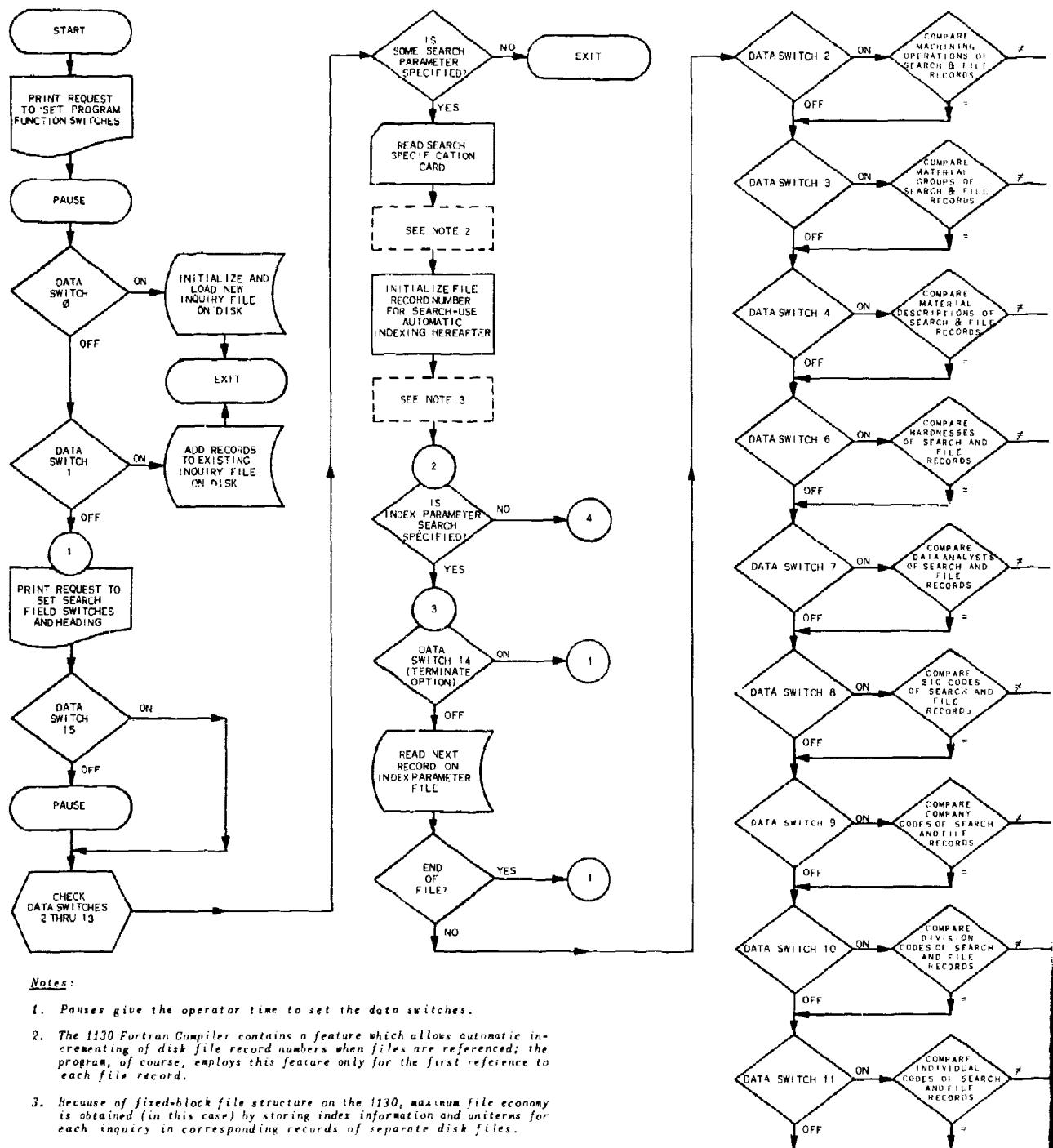
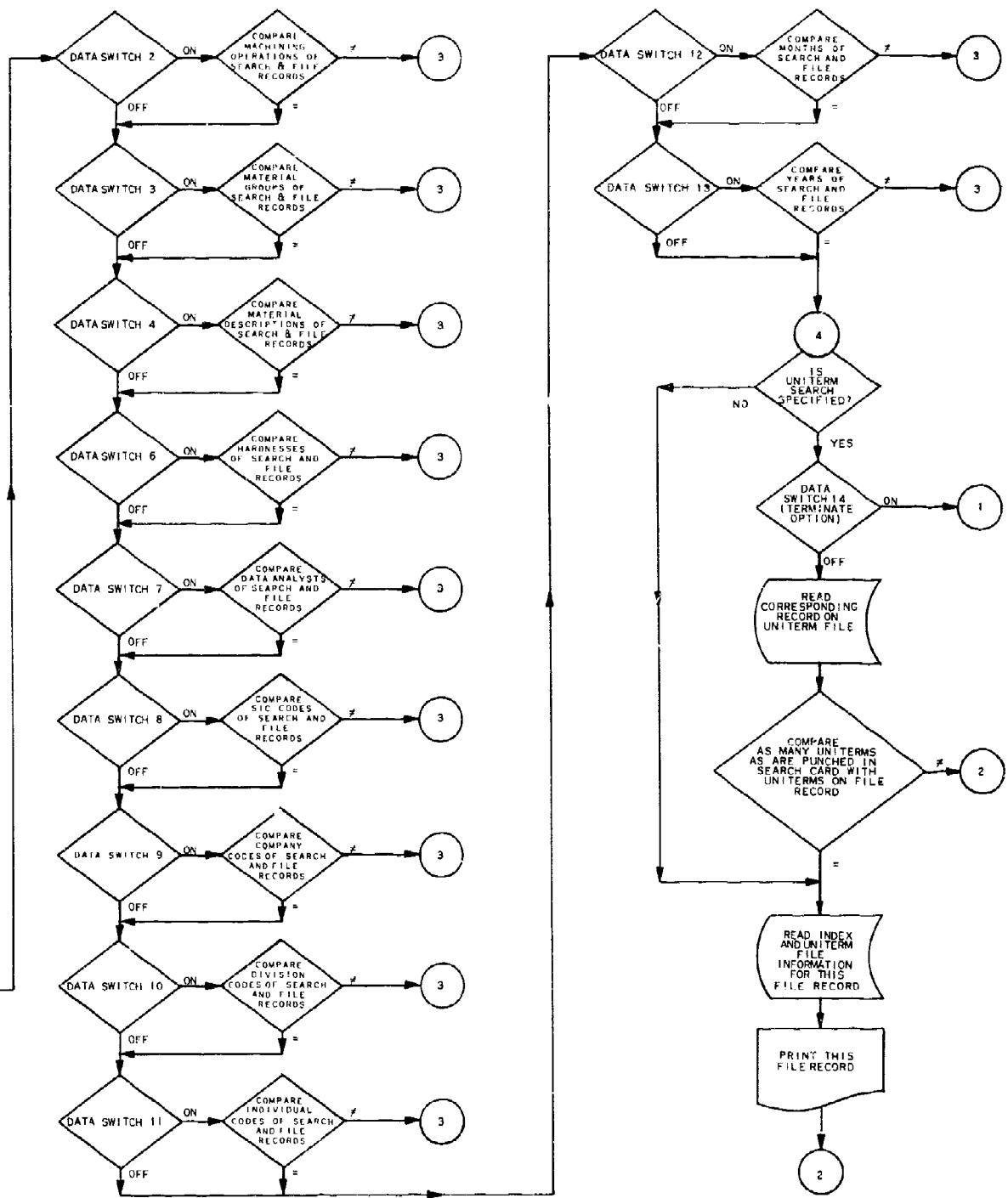


FIGURE 5

A.

FORTRAN PROGRAM TO STORE, ADD TO, OR SEARCH INQUIRY FILE



INQUIRY FILE SEARCH

CONTROL ON DATA SWITCH NO. 5 - UNITEM. CUT FLUID

OPER	TM	HARD	CD	HT	MG	MAT	DESCRP	ANAL	UNITEMS	CUT	FLUID	SIC	CO	DIV	INDIV	SEQ	DATE
170	0	0	0	0	301	INCOX750	J	X	X	X	X	3541	41	0	1	63	2 5
0	0	0	0	0	301	INCOX750	J	CUT	FLUID	CARB	TOOL	3541	42	5	1	97	3 5
0	0	0	0	0	301	WASPALOY	J	CUT	FLUID	CUT	TOOL	3722	79	0	1	112	3 5
85	0	0	0	0	301	INCOX750	J	CUT	FLUID	GEOM	-CORROSION	2911	82	1	1	119	3 5
55	0	0	0	0	301	INCOX750	B	CUT	FLUID	5722	9	9	1	138	3 5		
1	0	0	0	0	301	INCOX750	B	CUT	FLUID	5722	9	9	1	138	3 5		
85	0	0	0	0	301	INCO722	B	CUT	FLUID	5722	9	9	1	138	3 5		
55	0	0	0	0	301	INCO722	B	CUT	FLUID	5722	9	9	1	138	3 5		
1	0	0	0	0	301	INCOX750	B	CUT	FLUID	5722	9	9	1	138	3 5		
0	0	0	0	0	355	301A10W	N	CUT	FLUID	3359	44	2	1	140	3 5		
125	C31	0	0	106	H-11	J	CUT	FLUID	TOOL	LIFT	2911	96	2	1	147	4 5	
0	0	0	0	0	999	J	SURF	FIN	CUT	FLUID	3721	15	1	1	154	4 5	
275	0	0	0	0	999	K	SURF	-INTEGRITY	CUT	FLUID	9100	29	1	1	162	3 5	
500	0	0	0	3	999	J	CUT	FLUID	3722	79	0	1	178	4 5			
95	0	0	0	0	999	J	CUT	FLUID	3722	79	0	1	178	4 5			
76	0	0	0	0	999	J	CUT	FLUID	3722	79	0	1	178	4 5			
215	0	0	0	0	999	J	CUT	FLUID	3722	79	0	1	178	4 5			
155	0	0	0	261	ALNICO	B	CUT	FLUID	3541	26	0	2	207	5 5			
85	0	0	0	321	TIBALIMDLY	N	CUT	FLUID	3721	7	5	1	235	7 5			
56	0	0	0	321	TIBALIMDLY	N	CUT	FLUID	3721	7	5	1	235	7 5			
0	0	0	0	0	0	B	CUT	FLUID	3291	46	0	3	213	3 5			

CONTROL ON DATA SWITCHES NOS. 3,4, 4,5 - MATL GRP. 301: MATL DESCRIPT. INCO X750; UNITEM. CUT FLUID

OPER	TM	HARD	CD	HT	MG	MAT	DESCRP	ANAL	UNITEMS	CUT	FLUID	SIC	CO	DIV	INDIV	SEQ	DATE
170	0	0	0	0	301	INCOX750	X	X	X	X	X	3541	41	0	1	63	2 5
85	0	0	0	0	301	INCOX750	J	CUT	FLUID	3722	9	9	1	138	3 5		
55	0	0	0	0	301	INCOX750	B	CUT	FLUID	3722	9	9	1	138	3 5		
1	0	0	0	0	301	INCOX750	B	CUT	FLUID	3722	9	9	1	138	3 5		
0	0	0	0	0	301	INCOX750	J	CUT	FLUID	3722	9	3	2	29	1 8		

CONTROL ON DATA SWITCHES NOS. 2,3,4, 4,5 - OPERATION, 35 (DRILLING); MATL GRP. 301: MATL DESCRIPT. INCO X750; UNITEM. CUT FLUID

OPER	TM	HARD	CD	HT	MG	MAT	DESCRP	ANAL	UNITEMS	CUT	FLUID	SIC	CO	DIV	INDIV	SEQ	DATE
85	X	X	X	X	X	X	X	X	X	X	X	3722	9	9	1	138	3 5
85	0	0	0	0	301	INCOX750	B	CUT	FLUID	3722	9	9	1	138	3 5		

SEE APPENDIX. PAGE A-8

FIGURE 6

OUTPUT OF UNITERM FILE SEARCH

TOOL GEOM	085	301	TOOL GEOM TRBL SMOOTH MACHG - TECHNIQUES 110 006 085 040 125 301	487000 G660001 01 4 487000 660001
TOOL STD'S MACH TOOL-AUTOMATIC NC	001 085 075 155 020 050 100	301 051	TOOL GEOM TOOL DESIGN 500000 8580001 01 4 500000 580001	
TOOL GEOM	085	301		505000 G640006 01 4 505000 640006
TOOL GEOM CUT FLUID FEED RATE	020 085 100	301		506000 G630006 01 4 506000 630006
TOOL GEOM DRL GRNDG DEEP HOLE TOOL HDR	085 020 100 040 045 050	301		512000 G610007 01 4 512000 610007
TOOL GEOM MACHG - TECHNIQUE TOOL DESIGN TAP SPECS	075 110	300 281 076 301		605000 G590001 01 4 605000 590001
TOOL GEOM TORQUE THRUST TOOL FAILR	085	301		605003 G64001 01 4 605003 640001
TOOL GEOM STD SPEC FOREIGN	001 085	301		624002 G550001 01 4 624002 550001
MACHG DATA TOOL GEOM MACHG - TECHNIQUES	085	301		677000 G600001 01 4 677000 600001
TOOL GEOM DRILL - THEORY CUT FLUID-EFFECT	085	301		734007 G660001 01 4 734007 660001
DRL GRNDG CUTTER - GRNDG - SPECS	085 055 225	301	TOOL GRNDG TOOL GEOM 803004 8510013 01 4 803004 510013	
TOOL GEOM TORQUE THRUST SPIRAL PT	085	301		810001 8570001 01 4 810001 570001
SHEAR -ANGLE TOOL GEOM CUT FORCE	001 056 085	301		810006 G51001 01 4 810006 510001
MCHNBLYT -RATING TOOL GEOM TOOL LIFE CUT FLUID	001 085 056 075 070 110 100	301		811000 8620001 01 4 811000 620001
DRL GRNDG CUTTER - GRNDG - SPECS	085 055 225	301	TOOL GRNDG TOOL GEOM 803004 8510013 01 4 803004 510013	

OUTPUT OF FINAL TECHNICAL EVALUATED DATA

TURNING

CONDITION *TOOL MAT* *TOOL GEOMETRY* *DEPTH* *WEAR* *TOOL LIFE (MIN)* *SOURCE*
 MATERIAL *BHN* *TRAD* *IND* *STRUCTURE* *NAME*GRD* BR * SR *SCEA*REL* N.R.* *FLD* *CUT* *FEED* *LAND* *VS* *SPEED (FT/MIN)* *R=RECOMMENDED SPEED *VOL*REF*

HIGH TEMPERATURE ALLOYS - NICKEL BASE WROUGHT

INCO718	SOL TREAT 279	M2	0	15	15	5	.032	.52	.0600	.0070	.060	15	30	45	90	0	6 235	
		AUSTENITE	HSS									23	22	21	20	0		
INCO718	SOL TREAT 279	M2	0	15	15	5	.032	.11	.0600	.0020	.060	15	30	45	60	0	6 234	
		AUSTENITE	HSS									43	39	37	35	0		
INCO718	SOL TREAT 279	M2	0	15	15	5	.032	.11	.0600	.0050	.060	15	30	45	60	0	6 234	
		AUSTENITE	HSS									25	22	21	21	20		
INCO718	SOL TREAT 279	M2	0	15	15	5	.032	.11	.0600	.0070	.060	15	30	45	60	0	6 234	
		AUSTENITE	HSS									24	22	21	20	0		
INCO718	SOL TREAT 279	T15	0	15	15	5	.032	.11	.0600	.0050	.060	15	30	45	60	0	6 235	
		AUSTENITE	HSS									28	26	25	20	0		
INCO718	SOL TREAT 279	T15	0	15	15	5	.032	.11	.0600	.0050	.015	47	0	0	0	0	6 237	
		AUSTENITE	HSS									25	0	0	0	0		
INCO718	SOL TREAT 279	T15	0	15	15	5	.032	.11	.0600	.0070	.015	10	0	0	0	0	6 237	
		AUSTENITE	HSS									25	0	0	0	0		
INCO718	SOL TREAT 279	T15	0	15	15	5	.032	.11	.0600	.0090	.015	7	0	0	0	0	6 237	
		AUSTENITE	HSS									25	0	0	0	0		
INCO718	SOL TREAT 279 K68	C-2	0	5	45	15	5	.032	.11	.0600	.0090	.015	5	15	25	0	0	6 239
		AUSTENITE										160	125	110	0	0		
INCO718	SOL TREAT 279 K68	C-2	0	5	15	15	5	.032	.11	.0600	.0090	.015	15	30	45	0	0	6 238
		AUSTENITE										111	90	80	0	0		

SEE APPENDIX, PAGE A-9

FIGURE 8

COMPUTER PRINTOUT OF A SELECTIVE SEARCH ON SURFACE INTEGRITY FILE

RES STRS				
160	321			
SURF INTEGFOREIGN	RES STRS	CUT FLUID		
160	321		102401F 600001012794	
			102401 S600001	
SURF INTEGFOREIGN	RES STRS			
160 501	301 321		104501F 610001012794	
			104501 S610001	
SURF INTEGFOREIGN	RES STRS			
055 160 235	301 321		107201F 620001012794	
			107201 S620001	
SURF INTEGRES STRS DISTORTION SURF COND-NEUTL TRNSF FOREIGN				
058 160 501 650	251 051 076 321		294003F 660002012794	
			294008 660002	
RES STRS				
056 160 240 500 650 600 085	001 252 076 221 321 301 051		811003 680001012794	
			811003 680001	
SURF INTEGSURF INTG-DATA	RES STRS	SURF COND SURF FIN		
160	321		823003 550001012994	
			823003 550001	
SURF INTEGSURF INTG-DATA	RES STRS			
160	321		823005 580001012994	
			823005 580001	
SURF INTEGSURF INTG-DATA	RES STRS	SURF FIN CUT FLUID		
160	321		823006 590001012994	
			823006 590001 G	
SURF INTEGSURF COND SURF FIN RES STRS				
160 170 190	106 321 281 301		921000 630001012994	
			921000 630001	
SURF INTEGRES STRS MECH PROP-FATIGUE DISTORTION				
240 160 500 501 600 650 056	051 076 250 321		999009 670001012794	
			999009 670001	
RES STRS DISTORTION POST PROC-STRS RELF MECH PROP-FATIGUE				
056 240 160 500 055 155	051 001 321 301 221 200 300		999015 670001020894	
			999015 M670001	
SURF INTEGRES STRS MECH PROP-FATIGUE MECH PROP-STRS CORR				
155 160	320 321 051 300 301		999016 670001020894	
			999016 M670001	
CODE	6	SW - START	NSUM	1318

FORMULAE USED IN DETERMINING COST PER
PIECE IN FACE MILLING AND END MILLING

INSERTED TOOTH CUTTER - CARBIDE TIP OR HSS BLADE

$$C = M \left[\frac{D(e + L)}{3.82 Z f_t v} + \frac{2a + e + \frac{L}{r}}{r} + t_L + \frac{t_o}{N_t} + \frac{L t_c}{Z T_t} \right] + \frac{L}{Z T_t} \left[\frac{C_p}{(k_1 + 1)} + G t_s + \frac{G t_b}{k_2} + \frac{Z C_c}{k_3} + C_w \right] \quad (14)$$

S/HIN	FEEDING TIME	RAPID TRAVERSE TIME	LOAD & UNLOAD TIME	SETUP TIME	CUTTER BODY DEPRECIATION COST	CUTTER REHARSHEN COST	BLADE REHARSHEN COST	GRINDING WHEEL COST
-------	--------------	---------------------	--------------------	------------	-------------------------------	-----------------------	----------------------	---------------------

THROWAWAY INSERT CUTTER

$$C = M \left[\frac{D(e + L)}{3.82 Z f_t v} + \frac{2a + e + \frac{L}{r}}{r} + t_L + \frac{t_o}{N_t} + \frac{L t_c}{Z T_t} \right] + \frac{L}{Z T_t} \left[\frac{C_p}{(k_1 + 1)} + \frac{L}{Z T_t} \left[\frac{C_p}{(k_1 + 1)} + G t_s + \frac{Z C_c}{k_3} + C_w \right] \right] \quad (15)$$

S/HIN	FEEDING TIME	RAPID TRAVERSE TIME	LOAD & UNLOAD TIME	SETUP TIME	THROWAWAY INSERT TOTAL INDEX TIME	CUTTER BODY DEPRECIATION COST	THROWAWAY INDEX COST
-------	--------------	---------------------	--------------------	------------	-----------------------------------	-------------------------------	----------------------

SOLID HSS CUTTER

$$C = M \left[\frac{D(e + L)}{3.82 Z f_t v} + \frac{2a + e + \frac{L}{r}}{r} + t_L + \frac{t_o}{N_t} + \frac{L t_c}{Z T_t} \right] + \frac{L}{Z T_t} \left[\frac{C_p}{(k_1 + 1)} + G t_s + \frac{C t_b}{k_2} + \frac{L}{Z T_t} \left[\frac{C_p}{(k_1 + 1)} + G t_s + \frac{Z C_c}{k_3} + C_w \right] \right] \quad (16)$$

S/HIN	FEEDING TIME	RAPID TRAVERSE TIME	LOAD & UNLOAD TIME	SETUP TIME	CUTTER BODY DEPRECIATION COST	CUTTER REHARSHEN COST	CUTTER REHARSHEN COST	GRINDING WHEEL COST
-------	--------------	---------------------	--------------------	------------	-------------------------------	-----------------------	-----------------------	---------------------

SOLID BODY - BRAZED CARBIDE TIP CUTTER

$$C = M \left[\frac{D(e + L)}{3.82 Z f_t v} + \frac{2a + e + \frac{L}{r}}{r} + t_L + \frac{t_o}{N_t} + \frac{L t_c}{Z T_t} \right] + \frac{L}{Z T_t} \left[\frac{C_p}{(k_1 + 1)} + G t_s + \frac{C t_b}{k_2} + \frac{L}{Z T_t} \left[\frac{C_p}{(k_1 + 1)} + G t_s + \frac{Z C_c}{k_3} + C_w \right] \right] \quad (17)$$

S/HIN	FEEDING TIME	RAPID TRAVERSE TIME	LOAD & UNLOAD TIME	SETUP TIME	CUTTER BODY DEPRECIATION COST	CUTTER REHARSHEN COST	CARBIDE TIP COST	GRINDING WHEEL COST
-------	--------------	---------------------	--------------------	------------	-------------------------------	-----------------------	------------------	---------------------

COST AND PRODUCTION RATE FOR MILLING

INSERTED TOOTH - CARBIDE TIP OR HSS BLADE

DATA*	WORK	HARD*TOOL*	CUT *FEED/*TOOL*	*FEED*RAPD*LOAD*SET*-CUTR*BODY*BLAD*GRND*	*TOTAL*PROD*
SET*		SPD *TOOTH* LIFE*	*COST*TRAV*UNLD*	UP *CHNG*DEPR*SHPNRSET*COST*WHL*	**COST **RATE*
NO.* MATERIAL *	*	*F/M * IN *IN/TH*	* \$ * \$ * \$ * \$ *	* \$ * \$ * \$ * \$ *	**\$/PC.**PC/HR
101	WASPALOY	302 C-2	142 0.005 12.0	0.47 0.03 0.44 0.08 0.16 0.01 1.33 0.12 0.19 0.03	2.86 7.3
102	WASPALOY	302 C-2	92 0.005 24.0	0.75 0.03 0.44 0.08 0.08 0.01 0.66 0.06 0.09 0.01	2.19 6.4
103	WASPALOY	302 C-2	74 0.005 17.0	0.91 0.03 0.44 0.08 0.11 0.01 0.94 0.08 0.13 0.02	2.75 5.5

THROWAWAY INSERT

DATA*	WORK	HARD*TOOL*	CUT *FEED/*TOOL*	*FEED*RAPD*LOAD*SET*-INDX*BODY*INSERT*	*TOTAL*PROD*
SET*		SPD *TOOTH* LIFE*	*COST*TRAV*UNLD*	UP *INST*DEPR* COST *	**COST **RATE*
NO.* MATERIAL *	*	*F/M * IN *IN/TH*	* \$ * \$ * \$ * \$ *	* \$ * \$ * \$ * \$ *	**\$/PC.**PC/HR
14	201	WASPALOY	302 C-2	142 0.005 12.0	0.47 0.03 0.44 0.08 0.09 0.03 0.20
	202	WASPALOY	302 C-2	92 0.005 24.0	0.73 0.03 0.44 0.08 0.04 0.03 0.10
	203	WASPALOY	302 C-2	74 0.005 17.0	0.91 0.03 0.44 0.08 0.07 0.03 0.14

SOLID HIGH SPEED STEEL CUTTER

DATA*	WORK	HARD*TOOL*	CUT *FEED/*TOOL*	*FEED*RAPD*LOAD*SET*-CUTR*BODY*GRND*	*TOTAL*PROD*
SET*		SPD *TOOTH* LIFE*	*COST*TRAV*UNLD*	UP *CHNG*DEPR*SHPNR*WHL*	**COST **RATE*
NO.* MATERIAL *	*	*F/M * IN *IN/TH*	* \$ * \$ * \$ * \$ *	* \$ * \$ * \$ * \$ *	**\$/PC.**PC/HR
301	WASPALOY	302 M-2	32 0.011 20.0	0.61 0.03 0.44 0.08 0.04 0.07 0.34 0.04	1.45 8.7
302	WASPALOY	302 M-2	29 0.011 60.0	0.45 0.03 0.46 0.08 0.01 0.02 0.11 0.02	1.16 8.6
303	WASPALOY	302 M-2	25 0.011 113.0	0.53 0.03 0.44 0.08 0.00 0.01 0.05 0.01	1.16 8.1

COMPUTER PRINTOUT FOR INVESTIGATING RELATIONSHIPS BETWEEN MACHINING VARIABLES

AUTOMATIC COMPARES - OPERATION 001 (TURNING) ON FILE
REQUESTED VARIABLE - HARDNESS

COMPARE OPERATION AND FEED WITH OPERATION NO.1

卷之三

VARIABLE - HARNESS

1 51 6340

VARIABLE - HARDNESS

卷之三

313

VARIABLE - HARDNESS

1 51 4340

VARIABLE - HARDNESS

1 51 4340 47

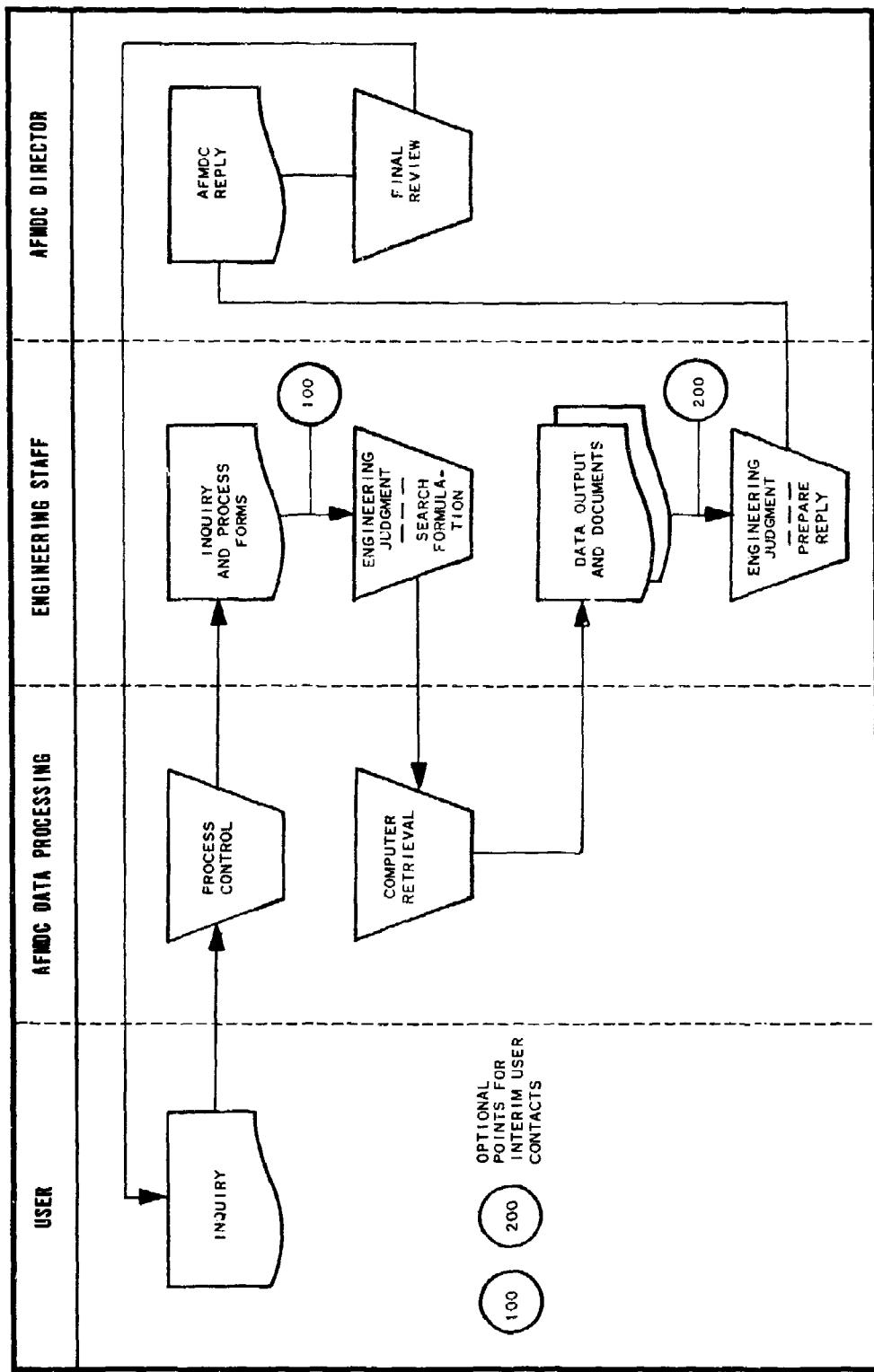
VARIABLE - HARDNESS

3

SEE APPENDIX. PAGE A-10

FIGURE 12

INQUIRY PROCESSING FLOW CHART



SEE APPENDIX, PAGE A-10

FIGURE 13

TYPICAL INQUIRY INPUT AND RESPONSE

AIR FORCE MACHINABILITY DATA CENTER

PO BOX 10000 • CINCINNATI, OHIO 45240

TELE 5127-5000 • Telex 131615-512

July 24, 1967

Yellowstone 5127-5000

TELE 5127-5000 • Telex 131615-512

Mr. R. A. Johnson
Manager, Manufacturing Engineering
Gentec Manufacturing Corporation
1780 Davidson Road
Hunter, Missouri 65114

Subject: Request for Face Milling, End Milling and Drilling
Recommendations for Inco 718 Perma in the Aged
Condition at 47 Rc --
Contract AF 131615-512

Thank you for your subject inquiry of July 20, 1967. In response to your
request we are pleased to furnish the following information:

Face Milling:

Carbide
Cutting Speed: 70 feet/minute
Feed: .006 inches/tooth/revolution

Tool Material: C-2
Tool Geometry: ECEA: 5°
AR: 0°
RR: 7°
C: 10°
CA: 45°
Highly Chlorinated Oil

HS:
Cutting Fluid:

25 feet/minute
.010 inches/tooth/revolution
Tool Material: T-15
Tool Geometry: AR: 0°
ECEA: 5°
RR: 30°
C: 10°
CA: 45°
Highly Chlorinated Oil

End Milling - Slotting:

35 feet/minute
Cutter Diameter: 1/2" 5/16" 1-2" 1-1/2"
Feed (in./inch): .0015 .002 .002 .003
Tool Material: T-15, M33, M34 or M36

RECOMMENDATION: For your future machining

AIR FORCE MACHINABILITY DATA CENTER
Robert E. Snider, Supervisor
Technical Ingistics

RES/Pg

SUMMARY OF SPECIFIC INQUIRIES BY TYPE OF INQUIRY

October 1, 1964 - July 31, 1968

	NO. OF INQUIRIES	AVERAGE PER MONTH	NO. OF INQUIRIES	AVERAGE PER MONTH
1. RECOMMENDATIONS FOR A SPECIFIC MACHINING SITUATION. <i>Typical Example: Requested recommendations for turning Waspaloy in the solution treated and aged condition.</i>	513	10.7	114	11.4
2. STARTING RECOMMENDATIONS FOR AN EXTENSIVE GROUP OF MACHINING SITUATIONS. <i>Typical Example: Requested machinability data on AM-350, S-816, HS-25, HS-31, Inconel X-50, Unitemp M-252 and Hastelloy R-235.</i>	1059	22.1	345	34.5
3. INFORMATION PERTAINING TO NEW MACHINING PROCESSES, EQUIPMENT AND TOOLS. <i>Typical Example: Requested information on the manufacturer of equipment called "Liquid Lathe".</i>	254	5.3	118	11.8
4. COORDINATION AND POTENTIAL USE OF AFNDC. <i>Typical Example: Requested detailed information on services available from AFNDC.</i>	194	4.0	65	6.5
5. VISITS TO THE CENTER. <i>Typical Example: Visited to coordinate with AFNDC to determine services available and to review System details.</i>	200	4.2	46	4.6
6. *REQUESTS FOR SPECIFIC DOCUMENTS, REPORTS, BOOKS, PAPERS, ETC. <i>Typical Example: Requested a list of reports available for machining of titanium. Also wanted cost of each report.</i>	341	7.1	108	10.8
7. GENERAL INFORMATION SUCH AS SAFETY PRACTICES, NAMES OF FIRMS HAVING CERTAIN MACHINING CAPABILITIES, TOOL MATERIAL PROPERTIES, ETC. <i>Typical Example: Requested the names of people to contact in the fields of metal removal such as EDM, ECM, ECG, EDG, USM, CMM, EDM, LBM, Abrasive Machining and Hot Machining.</i>	118	2.6	29	2.9
8. REQUESTS FOR BIBLIOGRAPHIES AND ABSTRACTS. <i>Typical Example: Request for bibliographies with abstracts covering use of ceramic tools and abrasives in machining various materials.</i>	40	.6	17	1.7

SUMMARY OF SPECIFIC INQUIRIES BY TYPE OF INQUIRY (cont.)

October 1, 1964 - July 31, 1969

	NO. OF INQUIRIES	AVERAGE PER MONTH	NO. OF INQUIRIES	AVERAGE PER MONTH
10/1/64-9/30/68	10/1/64-9/30/68	10/1/68-7/31/69	10/1/68-7/31/69	10/1/68-7/31/69
9. STATE-OF-THE-ART INFORMATION AND REPORTS. <i>Typical Example:</i> Suggestions for important manufacturing programs for the next five years in the field of material removal. Supply problem, approach and approximate funds.	49	1.0	9	.9
10. SPECIAL INQUIRIES AND REPORTS FOR U.S. AIR FORCE, MANUFACTURING TECHNOLOGY DIVISION. <i>Typical Example:</i> Requested a report on the progress during the last five years in machining of titanium and hard to machine materials - state of the art.	19	.4	-	-
11. EVALUATION, TRANSLATION AND REVIEW OF REPORTS, BOOKS, PAPERS. <i>Typical Example:</i> Requested an evaluation of a report published in Electro-Technology, October 1964, concerning adaptive control possibilities.	39	.8	7	.7
12. REQUESTS FOR INFORMATION ON METAL REMOVAL RATES. <i>Typical Example:</i> Requested information on maximum metal removal rates in turning and drilling of leaded steels.	50	1.0	4	.4
13. COMPARISON OF ONE PROCESS OR MATERIAL WITH ANOTHER. <i>Typical Example:</i> Requested a comparison of the machining of Inconel W with Inconel X in both solution treated and solution treated and aged conditions, primarily in turning but also drilling and milling if possible.	49	1.0	13	1.3
14. INFORMATION PERTAINING TO CUTTING FLUIDS. <i>Typical Example:</i> Requested cutting fluid recommendations for titanium and a wide variety of high temperature alloys and stainless steels.	75	1.6	13	1.3
15. INFORMATION ON MACHINABILITY RESEARCH. <i>Typical Example:</i> Requested machining information on the effect of work diameter on tool life, mathematical correlations of the various machining processes and the means of predicting the surface quality in milling.	232	4.8	181	18.1
16. INFORMATION PERTAINING TO ESTIMATING COST, SETTING TIME STANDARDS, AND PRODUCTION RATES IN MACHINING. <i>Typical Example:</i> Requested information including formulas that could be used to predict production rates and costs.	83	1.7	72	1.2
<i>* This total does not include requests for published data products such as AFMDC reports.</i>	<hr/>	<hr/>	<hr/>	<hr/>
TOTAL	3,315	69.1	1,141	114.1

FIGURE 15 (cont.)

ANALYSIS OF INQUIRIES BY STATE

Oct. 1, 1967 - July 31, 1968

10 STATES LEADING INQUIRIES			
STATES	COMPANIES	INDIVIDUALS	NO. OF INQUIRIES
CALIFORNIA	148	288	460
CONNECTICUT	47	76	142
ILLINOIS	96	135	227
INDIANA	60	110	165
MASSACHUSETTS	64	95	161
MICHIGAN	97	159	263
NEW JERSEY	56	106	219
NEW YORK	113	185	303
OHIO	304	586	1178
PENNSYLVANIA	114	188	279
TOTAL	1099	1928	3397
OTHER STATES SUBMITTING INQUIRIES			
ALABAMA	9	9	16
ARIZONA	13	23	47
ARKANSAS	4	4	4
COLORADO	10	23	42
DISTRICT OF COLUMBIA	14	20	29
DELAWARE	2	19	31
FLORIDA	13	25	72
GEORGIA	4	15	19
HAWAII	1	1	1
IOWA	9	11	15
KANSAS	9	13	19
KENTUCKY	14	24	49
LOUISIANA	3	8	13
MAINE	7	8	14
MARYLAND	26	34	54
MINNESOTA	18	26	35
MISSISSIPPI	2	2	2
MISSOURI	12	39	95
NEBRASKA	2	2	2
NEW HAMPSHIRE	6	6	7
NEW MEXICO	3	13	24
NORTH CAROLINA	8	10	24
OKLAHOMA	3	13	30
OREGON	5	6	10
RHODE ISLAND	8	8	13
SOUTH CAROLINA	4	4	8
TENNESSEE	11	24	65
TEXAS	22	43	93
UTAH	5	7	11
VERMONT	12	19	40
VIRGINIA	19	28	49
WEST VIRGINIA	8	9	19
WASHINGTON	8	30	45
WISCONSIN	24	36	57
TOTAL	318	562	1059
TOTAL FOR ALL STATES	1417	2480	44 6

GENERAL ANALYSIS OF INQUIRIES

FEBRUARY 1, 1966 - JULY 31, 1969

TYPE OF INQUIRY	NO. OF	AVERAGE PER	NO. OF	AVERAGE PER
	INQUIRIES	MONTH	INQUIRIES	MONTH
	2/1/66-9/31/68	2/1/66-9/31/68	10/1/68-7/31/69	10/1/68-7/31/69
ONE OPERATION ON ONE MATERIAL GROUP	360	11.3	142	14.2
ONE OPERATION ON A VARIETY OF MATERIAL GROUPS	225	7.0	155	15.5
SEVERAL OPERATIONS ON ONE MATERIAL GROUP	652	20.4	165	16.5
SEVERAL OPERATIONS ON SEVERAL MATERIAL GROUPS	445	13.9	206	20.6
UNITERM LINKED WITH AN OPERATION AND/OR GROUP	415	13.0	235	23.5
GENERAL MACHINING CONCEPTS (UNITERM)	623	19.4	238	23.8
TOTAL	2,720	85.0	1,141	114.1

ANALYSIS OF INQUIRIES BY MATERIAL GROUP

FEBRUARY 1, 1966 - JULY 31, 1969

MATERIAL GROUP	NO. OF	AVERAGE PER	NO. OF	AVERAGE PER
	INQUIRIES	MONTH	INQUIRIES	MONTH
	2/1/66-9/31/68	2/1/66-9/31/68	10/1/68-7/31/69	10/1/68-7/31/69
PLAIN CARBON & LOW ALLOY STEELS	732	22.9	222	22.2
ULTRA HIGH STRENGTH & TOOL STEELS	604	18.9	176	17.6
CAST IRON	193	6.0	82	8.2
STAINLESS STEELS	685	21.4	154	15.4
NICKEL ALLOYS	167	5.2	107	10.7
MARAGING STEELS	289	9.0	103	10.3
HIGH TEMPERATURE ALLOYS	890	27.8	294	29.4
TITANIUM ALLOYS	705	22.0	180	18.0
REFRACTORY ALLOYS	469	14.7	110	11.0
BERYLLIUM ALLOYS	194	6.0	57	5.7
ZIRCONIUM ALLOYS	99	3.1	42	4.2
ALUMINUM, MAGNESIUM, ZINC, LEAD & COPPER ALLOYS	315	9.9	96	9.6
PRECIOUS & RARE METALS	22	.7	8	.8
POWDER METALS	9	.3	6	.6
NONMETALLICS INCLUDING CERAMICS, PLASTICS, GRAPHITE & COMPOSITES	308	9.6	80	8.0
TOTAL	5,681	177.5	1,717	171.7

ANALYSIS OF INQUIRIES BY TYPE OF MACHINING OPERATION

FEBRUARY 1, 1966 - JULY 31, 1969

OPERATION	NO. OF INQUIRIES	AVERAGE PER MONTH	NO. OF INQUIRIES	AVERAGE PER MONTH
	2/1/66-9/30/68	2/1/66-9/30/68	10/1/68-7/31/69	10/1/68-7/31/69
CONVENTIONAL CHIP REMOVAL				
TURNING	1269	39.7	319	31.9
BORING	183	5.7	66	6.6
MILLING (GENERAL)	169	5.3	165	16.5
FACE MILLING	1011	31.6	260	26.0
END MILL SLOTTING	934	29.2	182	18.2
PERIPHERAL END MILLING	479	15.0	174	17.4
SLAB MILLING	46	1.4	18	1.8
THREAD MILLING	46	1.4	13	1.3
ALL OTHER TYPES OF MILLING	59	1.8	15	1.5
DRILLING	1175	36.7	300	30.0
GUN DRILLING	61	1.9	20	2.0
REAMING	777	24.3	160	16.0
TAPPING	861	27.0	166	16.6
GEAR CUTTING	29	.9	9	.9
BROACHING	155	4.8	43	4.3
ROUTING	30	.9	7	.7
BANDSAWING	115	3.6	17	1.7
HACKSAWING	54	1.7	19	1.9
TOTAL	7453	232.8	1953	195.3
CONVENTIONAL GRINDING				
GENERAL GRINDING	110	3.4	21	2.1
SURFACE GRINDING	731	22.8	66	6.6
CYLINDRICAL GRINDING	371	11.6	33	3.3
INTERNAL GRINDING	76	2.4	8	.8
CENTERLESS GRINDING	39	1.2	7	.7
GEAR GRINDING	27	.8	3	.3
THREAD GRINDING	28	.9	4	.4
ABRASIVE MACHINING	24	.8	5	.5
ABRASIVE BELT GRINDING	27	.8	5	.5
ABRASIVE CUTOFF	37	1.2	5	.5
HONING	17	.5	3	.3
TOTAL	1487	46.4	160	16.0
ALTERNATE MACHINING METHODS				
ELECTRICAL DISCHARGE MACHINING	162	5.1	48	4.8
ELECTROCHEMICAL MACHINING	155	4.8	43	4.3
ELECTROCHEMICAL GRINDING	68	2.1	27	2.7
CHEMICAL MACHINING	120	3.8	20	2.0
PHOTOCHEMICAL MACHINING	7	.2	-	-
ULTRASONIC MACHINING	30	.9	11	1.1
ELECTRON BEAM MACHINING	28	.9	2	.2
LASER MACHINING	37	1.2	6	.6
ION BEAM MACHINING	7	.2	-	-
ABRASIVE JET MACHINING	6	.2	1	.1
ELECTRO-STREAM MACHINING	9	.3	4	.4
TOTAL	629	18.7	162	16.2
MISCELLANEOUS				
BURNISHING	15	.4	3	.3
CONTROLLED ENERGY MACHINING	6	.2	1	.1
SUB-ZERO MACHINING	16	.5	1	.1
HOT MACHINING	6	.2	-	-
POLISHING	11	.3	3	.3
THREAD ROLLING	5	.2	1	.1
FLAME CUTTING	5	.2	-	-
TOTAL	64	2.0	9	.9
TOTAL	9833	382.0	2284	228.4

ANALYSIS OF UNITERM TYPE INQUIRIES

FEBRUARY 1, 1966 - JULY 31, 1969

UNITERM*	NO. OF REQUESTS	AVERAGE PER MONTH	NO. OF REQUESTS	AVERAGE PER MONTH
SURFACE INTEGRITY	183	5.7	73	7.3
NUMERICAL CONTROL	171	5.3	41	4.1
CUTTING FLUID	183	5.7	28	2.8
SURFACE FINISH	134	4.2	22	2.2
DISTORTION	84	2.6	12	1.2
CUTTING TOOLS - GENERAL	42	1.3	20	2.0
TOLERANCE	34	1.1	9	.9
G. RATIO	39	1.2	6	.6
CERAMIC TOOLS	29	.9	16	1.6
SUPER HARD HIGH SPEED STEEL	23	.7	5	.5
ADAPTIVE CONTROL	19	.6	11	1.1
RESIDUAL STRESS	32	1.0	10	1.0
TITANIUM CARBIDE	15	.5	6	.6
PRECISION MACHINING	14	.5	7	.7
TOOL SURFACE TREATMENT	12	.4	7	.7
METAL REMOVAL RATES	21	.6	11	1.1
TIME STANDARDS	18	.6	34	3.4
TOTAL	1053	32.9	318	31.8

* Partial list - 17 most active uniterm

SEE APPENDIX. PAGE A-12

FIGURE 19

AIR FORCE MACHINABILITY DATA CENTER

SUMMARY OF SPECIFIC INQUIRIES BY SIC* NUMBER

October 1, 1968 - July 31, 1968

SIC MAJOR GROUP NO.	SIC INDUSTRY NO.		<u>NUMBER OF INQUIRIES</u>	
		BY SIC INDUSTRY NO.	BY SIC MAJOR GROUP NO.	% OF TOTAL
91	FEDERAL GOVERNMENT		133	11.6
9100	U.S. DEPARTMENT OF DEFENSE	4		
9100	USAF - WRIGHT FIELD	16		
9100	USAF - APO, NEW YORK	5		
9100	USAF - TINKER AIR FORCE BASE	2		
9100	U.S. ARMY	8		
9100	U.S. NAVY	3		
9100	NATIONAL AERONAUTICS & SPACE ADMINISTRATION	11		
9190	BSDA DEPARTMENT OF COMMERCE	2		
9190	NATIONAL BUREAU OF STANDARD	1		
**9191	STATE TECHNICAL SERVICE PROGRAMS	41		
9192	SMALL BUSINESS ADMINISTRATION	40		
19	ORDNANCE AND ACCESSORIES		12	1.5
27	PRINTING, PUBLISHING, AND ALLIED INDUSTRIES		12	1.1
28	CHEMICALS AND ALLIED PRODUCTS		7	.6
29	PETROLEUM REFINING AND RELATED INDUSTRIES		17	1.4
32	STONE, CLAY, GLASS, AND CONCRETE PRODUCTS		14	1.2
33	PRIMARY METAL INDUSTRIES		49	4.2
34	FABRICATED METAL PRODUCTS, EXCEPT ORDNANCE, MACHINERY, AND TRANSPORTATION EQUIPMENT		44	3.8
35	MACHINERY, EXCEPT ELECTRICAL		267	23.4
36	ELECTRICAL MACHINERY, EQUIPMENT AND SUPPLIES		88	7.7
37	TRANSPORTATION EQUIPMENT		337	29.5
3721	AIRCRAFT AND MISSILES	186		
3722	AIRCRAFT ENGINES & ENGINES PARTS - MISSILE ENGINES	70		
3729	AIRCRAFT PARTS & AUXILIARY EQUIPMENT - MISSILE PARTS	49		
	OTHERS	32		
38	PROFESSIONAL, SCIENTIFIC, AND CONTROLLING INSTRUMENTS: PHOTOGRAPHIC AND OPTICAL GOODS: WATCHES AND CLOCKS		7	.6
39	JEWELRY, PRECIOUS METALS		3	.3
50	WHOLESALE TRADE		13	1.1

* Standard Industrial Classification Manual (SIC). Executive Office of the President, Bureau of the Budget, 1967

** This SIC Number Was Assigned Because of the Special Significance of the State Technical Service Program

NUMBER OF INQUIRIES

SIC MAJOR GROUP NO.	SIC INDUSTRY NO.	BY SIC INDUSTRY NO.	BY SIC MAJOR GROUP NO.	% OF TOTAL
73	MISCELLANEOUS BUSINESS SERVICES		43	3.7
82	EDUCATIONAL SERVICES		55	4.9
86	NONPROFIT MEMBERSHIP ORGANIZATIONS		5	.4
89	MISCELLANEOUS SERVICES		35	3.0
	TOTALS		1141	100.0%

AIR FORCE MACHINABILITY DATA CENTER

GOVERNMENT AGENCIES AND SERVICES SUPPORTED DIRECTLY AND INDIRECTLY BY AFMDC INQUIRIES

October 1, 1968 - July 31, 1969

CATEGORY

- A. TOTAL INQUIRIES FOR THE PERIOD OCTOBER 1, 1968 THROUGH JULY 31, 1969 1,141
- B. INQUIRIES BY ACADEMIC AND COMMERCIAL SOURCES NOT IDENTIFIABLE WITH GOVERNMENT PURPOSES 80
- C. INQUIRIES IDENTIFIED AS SUPPORTING GOVERNMENT PURPOSES 1,081
- D. DIRECT INQUIRIES BY GOVERNMENT AGENCIES (USAF, NASA, etc.) 143
- E. INQUIRIES BY CONTRACTORS IDENTIFIED DIRECTLY WITH SPECIFIC GOVERNMENT SERVICES OR AGENCIES (USAF, NASA, etc.) 416
- F. INQUIRIES BY COMPANIES IDENTIFIED INDIRECTLY WITH SPECIFIC GOVERNMENT SERVICES OR AGENCIES (USAF, NASA, etc.) 522

	AIR FORCE	U. S. NAVY	U. S. ARMY	AEC	NASA	STSP*	SB&**	TOTAL
D. DIRECT INQUIRIES BY GOVERNMENT AGENCIES	23	3	10	14	12	41	40	143
E. INQUIRIES BY CONTRACTORS IDENTIFIED DIRECTLY WITH SPECIFIC GOVERNMENT SERVICES OR AGENCIES (USAF, NASA, etc.)	337	17	14	13	35	-	-	416
F. INQUIRIES BY COMPANIES IDENTIFIED INDIRECTLY WITH SPECIFIC GOVERNMENT SERVICES OR AGENCIES (USAF, NASA, etc.)	423	24	19	14	42	-	-	522
C. TOTAL TECHNICAL INQUIRIES ASSISTING GOVERNMENT PURPOSES	763	44	43	41	89	41	40	1,081

- * STATE TECHNICAL SERVICES PROGRAMS
- ** SMALL BUSINESS ADMINISTRATION TECHNOLOGY UTILIZATION PROGRAMS

SEE APPENDIX, PAGE A-13

FIGURE 21

SUMMARY OF INQUIRIES PROCESSED BY AFMDC FOR STSP* & SBA**

October 1, 1988 - July 31, 1989

NUMBER OF INQUIRIES FOR STSP*	
<u>STATE</u>	<u>NO. OF INQUIRIES</u>
VERMONT	6
ARIZONA	5
INDIANA	4
MAINE	3
MINNESOTA	3
OHIO	3
WASHINGTON, D.C.	3
MICHIGAN	2
MISSOURI	2
NORTH CAROLINA	2
WEST VIRGINIA	2
GEORGIA	1
NEW YORK	1
PENNSYLVANIA	1
TENNESSEE	1
TEXAS	1
VIRGINIA	1
TOTAL	41

NUMBER OF INQUIRIES FOR SBA**	
<u>STATE</u>	<u>NO. OF INQUIRIES</u>
TEXAS	9
WASHINGTON, D.C.	8
PENNSYLVANIA	6
OHIO	4
MASSACHUSETTS	3
NEW YORK	3
CALIFORNIA	2
MICHIGAN	2
COLORADO	1
MINNESOTA	1
WASHINGTON	1
TOTAL	40

STSP* - STATE TECHNICAL SERVICES PROGRAMS

SBA** - SMALL BUSINESS ADMINISTRATION TECHNOLOGY
UTILIZATION PROGRAMS

COMPANIES & AGENCIES SUBMITTING INQUIRIES TO AFMDC

October 1, 1964 - September 30, 1968

ABEX CORPORATION, MAHWAH, N.J.
ABORN, DR. ROBERT H., MILLINGTON, N.J.
ACF INDUSTRIES, INC., ALBUQUERQUE, N.M.
ACCURATE BUSHING COMPANY, GARWOOD, N.J.
ACCURATE DIAMOND TOOL CORP., HACKENSACK, N.J.
ACRALOC CORPORATION, OAK RIDGE, TENN.
ADAMAS CARBIDE CORP., KENILWORTH, N.J.
ADAPTO, GOODYEAR, ARIZ.
ADKINS & HUMINIK, ALEXANDRIA, VA.
AEROJET-GENERAL CORPORATION, AZUSA, CALIF.
AEROJET-GENERAL CORPORATION, CLAREMONT, CALIF.
AEROJET-GENERAL CORPORATION, DOWNEY, CALIF.
AEROJET-GENERAL CORPORATION, SACRAMENTO, CALIF.
AEROJET-GENERAL CORPORATION, DAYTON, OHIO
AERONCA INC., MIDDLETOWN, OHIO
AEROPROJECTS INC., WEST CHESTER, PA.
AEROQUIP CORPORATION, JACKSON, MICH.
AEROQUIP CORPORATION, VAN WERT, OHIO
AEROSPACE CORPORATION, SAN BERNARDINO, CALIF.
AEROSPACE RESEARCH APPLICATIONS CENTER,
 BLOOMINGTON, IND.
AIR FORCE HEADQUARTERS, WASHINGTON, D.C.
AIR FORCE REPRESENTATIVE, THE MARTIN CO.,
 DENVER, COLO.
AIRESEARCH MANUFACTURING COMPANY, PHOENIX, ARIZ.
AIRESEARCH MANUFACTURING COMPANY, LOS ANGELES, CALIF.
ALCO PRODUCTS, INC., SCHENECTADY, N.Y.
ALEXANDER & ASSOCIATES, CINCINNATI, OHIO
ALLEHENY-LUDLUM STEEL CORP., DUNKIRK, N.Y.
ALLEHENY-LUDLUM STEEL CORP., PITTSBURGH, PA.
ALLIANCE TOOL COMPANY INC., ST. LOUIS, MO.
ALLIED CHEMICAL CORP., MORRISTOWN, N.J.
ALLIS-CHALMERS MANUFACTURING COMPANY, NORWOOD, OHIO
ALLIS-CHALMERS MANUFACTURING COMPANY, MILWAUKEE, WISC.
ALTAMIL CORPORATION, CHAMBERS AIRCRAFT DIV.,
 SHELBYVILLE, IND.
ALUMINUM COMPANY OF AMERICA, LAFAYETTE, IND.
ALUMINUM COMPANY OF AMERICA, PITTSBURGH, PA.
ALUMINUM SMOULERS RESEARCH INSTITUTE, CHICAGO, ILL.
AMACOIL TOOL DIVISION, CHICAGO, ILL.
AMBERG & USLER, INC., EAST ORANGE, N.J.
AMERICAN AIRLINES INC., TULSA, OKLA.
AMERICAN BOSCH ARMA CORPORATION, SPRINGFIELD, MASS.
AMERICAN BOSCH ARMA CORPORATION, GARDEN CITY, N.Y.
AMERICAN BRAKE SHOE COMPANY, ELYRIA, OHIO
AMERICAN BUSINESS DEVELOPMENT, LOS ANGELES, CALIF.
AMERICAN CAN COMPANY, SAN FRANCISCO, CALIF.
AMERICAN CAN COMPANY, GENEVA, N.Y.
AMERICAN CYANAMID COMPANY, SANFORD, ME.
AMERICAN HELLER CORPORATION, DETROIT, MICH.
AMERICAN INSTITUTE OF AERONAUTICS, LOS ANGELES, CALIF.
AMERICAN INSTITUTE OF MINING METALLURGICAL &
 PETROLEUM ENGINEERS, NEW YORK, N.Y.
AMERICAN IRON AND STEEL INST., NEW YORK, N.Y.
AMERICAN LAUNDRY MACHINERY INDUSTRIES, CINCINNATI, OHIO
AMERICAN MACHINE & FOUNDRY CO., YORK, PA.
AMERICAN MACHINIST, CLEVELAND, OHIO
AMERICAN OIL COMPANY, CHICAGO, ILL.
AMERICAN OIL COMPANY, WHITING, IND.
AMERICAN SAW & MANUFACTURING COMPANY,
 EAST LONGMEADOW, MASS.
AMERICAN SOCIETY FOR METALS, METALS PARK, OHIO
AMERICAN SOCIETY OF TOOL & MANUFACTURING ENGINEERS,
 DEARBORN, MICH.
AMERICAN TOOL COMPANY, KALAZAMOO, MICH.
AMERICAN TOOL WORKS, CINCINNATI, OHIO

AMERICAN WELDING & MANUFACTURING CO., WARREN, OHIO
AMES LABORATORY, AMES, IOWA
AMETEK INC., SELLERSVILLE, PA.
AMMUNICATION PROCUREMENT & SUPPLY AGENCY, JOLIET, ILL.
AMPCO METAL INC., MILWAUKEE, WISC.
AMPHENOL CORPORATION, CHICAGO, ILL.
AMTEL, INC., PEABODY, MASS.
ANDERSON BROTHERS MANUFACTURING CO., ROCKFORD, ILL.
ANDREWS AIR FORCE BASE, WASHINGTON, D. C.
ANGUT ENGINEERING COMPANY, ELK GROVE VILLAGE, ILL.
ANZON COMPANY, INC., EL MONTE, CALIF.
APEX CORPORATION, INDIANAPOLIS, IND.
API CORPORATION, MIAMI, FLA.
APPLIED OCEANICS, LOS ANGELES, CALIF.
ARGONNE NATIONAL LABORATORY, ARGONNE, ILL.
ARIZONA STATE UNIVERSITY, TEMPE, ARIZ.
ARIZONA, UNIVERSITY OF, TUCSON, ARIZ.
ARKWIN INDUSTRIES INC., WESTBURY, N.Y.
ARMCO STEEL CORPORATION, TORRANCE, CALIF.
ARMCO STEEL CORPORATION, BALTIMORE, MD.
ARMCO STEEL CORPORATION, CINCINNATI, OHIO
ARMCO STEEL CORPORATION, MIDDLETOWN, OHIO
ARMSTRONG BLUM MFG. COMPANY, CINCINNATI, OHIO
ARMY PROCUREMENT DISTRICT, CHICAGO, ILL.
ARNO ADHESIVE TAPE, INC., MICHIGAN CITY, IND.
ARO, INC., ARNOLD AIR FORCE STATION, TENN.
ARROW GEAR COMPANY, OWNERS GROVE, ILL.
ARROWSMITH TOOL & MFG. CORP., LOS ANGELES, CALIF.
ASTRO MET ASSOCIATES, INC., CINCINNATI, OHIO
ASTRO TECH, INC., MINNEAPOLIS, MINN.
ASTROSYSTEMS INTERNATIONAL INC., ROCKAWAY, N.J.
ATI INDUSTRIES, ESCONDIDO, CALIF.
ATLANTIC RESEARCH CORPORATION, GAINSVILLE, VA.
ATLANTIC RICHFIELD COMPANY, PHILADELPHIA, PA.
ATLAS ALLOYS, CLEVELAND, OHIO
ATLAS PORTABLE EQUIPMENT CO., OAK PARK, MICH.
AUTOMATION ACCESSORIES INC., CINCINNATI, OHIO
AUTOMATION ACCESSORIES INC., DAYTON, OHIO
AUTOMATION INDUSTRIES INC., ABILENE, TEX.
AUTOMATION INDUSTRIES, INC., STERLING, VA.
AUTOMATIC SERVICENTER INC., BALTIMORE, MD.
AVCO CORPORATION, STRATFORD, CONN.
AVCO CORPORATION, RICHMOND, IND.
AVCO CORPORATION, WESTBORO, MASS.
AVCO CORPORATION, WILMINGTON, MASS.
AVCO CORPORATION, COLDWATER, OHIO
AVCO CORPORATION, NASHVILLE, TENN.
AVEY MACHINE TOOL COMPANY, COVINGTON, KY.
AVIATION WEEK & SPACE TECHNOLOGY, NEW YORK, N.Y.
AVILDSEN TOOL & MACHINES INC., NEW YORK, N.Y.
BACHAN MANUFACTURING CO., POMPANO BEACH, FLA.
BACKER TOOL & DIE, CINCINNATI, OHIO
BADGER, F. SIDNEY, WOODLAND HILLS, CALIF.
BADGETT & SMITH ASSOCIATES INC., CINCINNATI, OHIO
BAKER OIL TOOLS INC., LOS ANGELES, CALIF.
BALDWIN-LIMA-HAMILTON, BURNHAM, PA.
BALL BROS. RESEARCH CORP., BOULDER, COLO.
BARBER-COLMAN COMPANY, ROCKFORD, ILL.
BARRY-WEHMILLER COMPANY, ST. LOUIS, MO.
BATH IRON WORKS, BATH, ME.
BATTELLE MEMORIAL INSTITUTE, LOS ANGELES, CALIF.
BATTELLE MEMORIAL INSTITUTE, COLUMBUS, OHIO
BATTELLE MEMORIAL INSTITUTE, RICHLAND, WASH.
BAUSCH & LOMB INCORPORATED, ROCHESTER, N.Y.
BAY SWISS MFG. CO., INC., EL SEGUNDO, CALIF.

BDSA DEPARTMENT OF COMMERCE, WASHINGTON, D.C.
BEECH AIRCRAFT CO., WICHITA, KAN.
BELL HELICOPTER COMPANY, FT. WORTH, TEX.
BELL & HOWELL RESEARCH CENTER, PASADENA, CALIF.
BELLows-VALVAIR CORPORATION, CINCINNATI, OHIO
BELOIT CORPORATION, BELOIT, WISC.
BELOIT EASTERN CORPORATION, DOWNTON, PA.
BENDIX CORPORATION (THE), SOUTH BEND, IND.
BENDIX CORPORATION (THE), GREENFIELD, MASS.
BENDIX CORPORATION (THE), DETROIT, MICH.
BENDIX CORPORATION (THE), SOUTHFIELD, MICH.
BENDIX CORPORATION (THE), KANSAS CITY, MO.
BENDIX CORPORATION (THE), TETERBORG, N.J.
BENDIX CORPORATION (THE), SIDNEY, N.Y.
BENDIX CORPORATION (THE), YORK, PA.
BENEDICT-MILLER INC., LYNDHURST, N.J.
BENNET TECHNICAL SERVICES INC., CINCINNATI, OHIO
BENRUS WATCH COMPANY, WATERBURY, CONN.
BERCO MANUFACTURING COMPANY, WATERBURY, CONN.
BERYLliUM CORPORATION OF AMERICA (THE),
HAZELTON, PA.
BERYLliUM CORPORATION OF AMERICA (THE),
READING, PA.
BESLY-WELLES CORPORATION, SOUTH BELOIT, ILL.
BESLY-WELLES CORPORATION, CINCINNATI, OHIO
BETHLEHEM STEEL CORPORATION, BETHLEHEM, PA.
BIGGER COMPANY, C. M., READING, OHIO
BLACK & DECKER MFG. CO., TOWSON, MD.
BLISS COMPANY, E.W., SOUTH PORTLAND, ME.
BOEING COMPANY (THE), WHCHITA, KAN.
BOEING COMPANY (THE), NEW ORLEANS, LA.
BOEING COMPANY (THE), PHILADELPHIA, PA.
BOEING COMPANY (THE), AUBURN, WASH.
BOEING COMPANY (THE), RENTON, WASH.
BOEING COMPANY (THE), SEATTLE, WASH.
BONAR COMPANY, CINCINNATI, OHIO
BOOZ ALLEN APPLIED RESEARCH INC., NEW YORK, N.Y.
BOOZ ALLEN APPLIED RESEARCH INC., INDEPENDENCE, OHIO
BORG-WARNER CORPORATION, CHICAGO, ILL.
BORG-WARNER CORPORATION, DES PLAINES, ILL.
BORG-WARNER CORPORATION, FREMONT, OHIO
BOSTROM CORPORATION, MILWAUKEE, WISC.
BRAD FOOTE GEAR WORKS INC., CICERO, ILL.
BRANDS MACHINING COMPANY, PORTLAND, PA.
BRASS & BRONZE INSTITUTE, CHICAGO, ILL.
BRIDGEPORT BRASS COMPANY, INDIANAPOLIS, IND.
BRIDGEPORT, UNIVERSITY OF, BRIDGEPORT, CONN.
BRIGGS & STRATTON CORPORATION, MILWAUKEE, WISC.
BRIGHAM YOUNG UNIVERSITY, PROVO, UTAH
BROOKS & PERKINS INC., DETROIT, MICH.
BROWN & ROOT INC., HOUSTON, TEX.
BROWN & SHARPE MANUFACTURING CO., DAYTON, OHIO
BRUBAKER TOOL CORPORATION, MILLERSBURG, PA.
BRUNSWICK CORPORATION, MUSKEGON, MICH.
BRUSH BERYLLIUM COMPANY (THE), HAYWARD, CALIF.
BRUSH BERYLLIUM COMPANY (THE), CLEVELAND, OHIO
BRUSH BERYLLIUM COMPANY (THE), ELMORE, OHIO
BUCKEYE FOUNDRY COMPANY, CINCINNATI, OHIO
BUDD COMPANY, NEWARK, DELA.
BUERK TOOL & MACHINE CORPORATION, BUFFALO, N.Y.
BUHR MACHINE TOOL COMPANY, DETROIT, MICH.
BULLARD COMPANY, (THE), BRIDGEPORT, CONN.
BUNKER-RAMO CORPORATION, CLEVELAND, OHIO
BURGESS-NORTON MANUFACTURING CO., GENEVA, ILL.
BURGMMASTER CORPORATION, CINCINNATI, OHIO
BURNDY CORPORATION, NORWALK, CONN.
BURSON MARSTELLER ASSOCIATES, NEW YORK, N.Y.

CADILLAC GAGE COMPANY, COSTA MESA, CALIF.

CADILLAC GAGE COMPANY, ROSEVILLE, MICH.
CALIFORNIA GENERAL INC., CHULA VISTA, CALIF.
CALIFORNIA STATE PRISON, SAN QUENTIN, CALIF.
CALIFORNIA, UNIVERSITY OF, LIVERMORE, CALIF.
CAMCAR SCREW & MANUFACTURING CO., ROCKFORD, ILL.
CAMERON IRON WORKS, HOUSTON, TEX.
CARBORUNDUM COMPANY (THE), NIAGARA FALLS, N.Y.
CARLISLE CHEMICAL WORKS INC., READING, OHIO
CARLTON MACHINE TOOL COMPANY, CINCINNATI, OHIO
CARNEGIE INSTITUTE OF TECHNOLOGY, PITTSBURGH, PA.
CARPENTER STEEL COMPANY (THE), READING, PA.
CARR TOOL COMPANY, NORWOOD, OHIO
CARRIER AIR CONDITIONING CO., SYRACUSE, N.Y.
CATERPILLAR TRACTOR COMPANY, DEACATUR, ILL.
CATERPILLAR TRACTOR COMPANY, PEORIA, ILL.
CAVITRON ULTRASONICS, INC., LONG ISLAND, N.Y.
CDS ENGINEERING INC., SANTA CLARA, CALIF.
CEEMCO, CINCINNATI, OHIO
CELANESE CORPORATION, NARROWS, VA.
CENTRAL FABRICATORS INC., CINCINNATI, OHIO
CENTRAL MACHINE WORKS, INDIANAPOLIS, IND.
CENTRO CORPORATION, DAYTON, OHIO
CHAMBERLAIN MANUFACTURING CORPORATION, WATERLOO, IOWA
CHANDLER EVANS INC., WEST HARTFORD, CONN.
CHASE BRASS & COPPER CO., SOLON, OHIO
CHASE MANHATTAN BANK, NEW YORK, N.Y.
CHEMCUT CORPORATION, STATE COLLEGE, PA.
CHICAGO CUTTING DIE COMPANY, CHICAGO, ILL.
CHICAGO PNEUMATIC TOOL CO., UTICA, N.Y.
CHICAGO PROCUREMENT DETACHMENT, CHICAGO, ILL.
CHROMALLOY AMERICAN CORP., WEST NYACK, N.Y.
CHRYSLER CORPORATION, NEW ORLEANS, LA.
CHRYSLER CORPORATION, DEARBORN, MICH.
CHUCKING MACHINE PRODUCTS INC., FRANKLIN PARK, ILL.
CINCINNATI LATHE & TOOL COMPANY, CINCINNATI, OHIO
CINCINNATI MILLING MACHINE COMPANY (THE),
CINCINNATI, OHIO
CINCINNATI MILLING MACHINE COMPANY (THE),
WILMINGTON, OHIO
CINCINNATI MINE MACHINERY CO., CINCINNATI, OHIO
CINCINNATI SHAPER COMPANY, WHITEMAN, OHIO
CINCINNATI SUB-ZERO PRODUCTS INC., CINCINNATI, OHIO
CINCINNATI, UNIVERSITY OF, CINCINNATI, OHIO
CITRUS COLLEGE, AZUSA, CALIF.
CLEARINGHOUSE FOR FEDERAL SCIENTIFIC & TECHNICAL
INFORMATION, SPRINGFIELD, VA.
CLECO PNEUMATIC, CINCINNATI, OHIO
CLEVELAND AUTOMATIC MACHINE TOOL CO., CINCINNATI, OHIO
CLEVELAND PNEUMATIC TOOL CO., (THE), CLEVELAND, OHIO
CLEVELAND TWIST DRILL COMPANY, CLEVELAND, OHIO
CLEVITE CORPORATION, CLEVELAND, OHIO
CLIMAX MOLYBDENUM CO., NEW YORK, N.Y.
CLIMCO PRODUCTS INC., CINCINNATI, OHIO
COBALT INFORMATION CENTER, COLUMBUS, OHIO
COLLINS RADIO COMPANY, CEDAR RAPIDS, IOWA
COLLINS RADIO COMPANY, DALLAS, TEX.
COLT INDUSTRIES INC., BELOIT, WISC.
COMMERCIAL SCREW PRODUCTS, INC., CLEVELAND, OHIO
COMSTOCK & WEScott INC., CAMBRIDGE, MASS.
CONAX CORPORATION, BUFFALO, N.Y.
CONCORD-RENN COMPANY, CINCINNATI, OHIO
CONTINENTAL AVIATION & ENGINEERING CORP.,
DETROIT, MICH.
CONTINENTAL AVIATION & ENGINEERING CORP.,
TOLEDO, OHIO
CONTINENTAL COPPER & STEEL CO., BRAEBURN, PA.
CONTINENTAL-EMSCO COMPANY, GARLAND, TEX.
CONTINENTAL MOTORS CORPORATION, MUSKEGON, MICH.
CONTINENTAL TOOL COMPANY, DETROIT, MICH.

CONTROL MECHANISMS INC., PHILADELPHIA, PA.
CONTROLS COMPANY OF AMERICA, JACKSONVILLE, ARK.
CONVER STEEL & WIRE CO. INC., NEW YORK, N.Y.
COORS CO., INC., H. F., INGLEWOOD CALIF.
COORS PORCELAIN COMPANY, GOLDEN, COLO.
COPAT CORPORATION, BEECH GROVE, IND.
CORDELL ASSOCIATES, LOS ANGELES, CALIF.
CORHART REFRactories COMPANY, BUCHANNON, W. VA.
CORNELL AERONAUTICAL LABORATORY INC., BUFFALO, N.Y.
CORNING GLASS WORKS, CORNING, N.Y.
CORPLAN ASSOCIATES, CHICAGO, ILL.
COX MANUFACTURING CO., INC., SAN ANTONIO, TEX.
CRAFTNEEDS INC., CINCINNATI, OHIO
CRANE COMPANY, CHICAGO, ILL.
CRANE COMPANY, NEW CASTLE, PA.
CRUCIBLE STEEL COMPANY OF AMERICA, CINCINNATI, OHIO
CRUCIBLE STEEL COMPANY OF AMERICA, PITTSBURGH, PA.
CUMMINS ENGINE COMPANY INC., COLUMBUS, IND.
CURTISS-WRIGHT CORP., CALDWELL, N.J.
CURTISS-WRIGHT CORP., WOOD-RIDGE, N.J.
CURTISS-WRIGHT CORP., BUFFALO, N.Y.
CUSTOM TOOLING CO., CINCINNATI, OHIO
CYCLOPS CORPORATION, BRIDGEVILLE, PA.
CYCLOPS CORPORATION, PITTSBURGH, PA.

DALMO VICTOR COMPANY, BELMONT, CALIF.
DANA CORPORATION, RICHMOND, IND.
DANA CORPORATION, TOLEDO, OHIO
DANVILLE METAL STAMPING, DANVILLE, ILL.
DATA INFORMATION GATHERING SERVICE, PALO ALTO, CALIF.
DAVEWOOD SUPPLY COMPANY, ROCKFORD, ILL.
DAYTON MALLEABLE IRON CO., DAYTON, OHIO
DAYTON RESEARCH INSTITUTE, UNIVERSITY OF, DAYTON, OHIO
DEA PRODUCTS, TEMPE, ARIZ.
DEERE & COMPANY, MOLINE, ILL.
DEFENSE CERAMIC INFORMATION CENTER, COLUMBUS, OHIO
DEL MACHINE & WELDING WORKS INC., HOUSTON, TEX.
DELAVAL TURBINE, INC., TRENTON, N.J.
DENVER, UNIVERSITY OF, DENVER, COLO.
DEPUY MANUFACTURING COMPANY, WARSAW, IND.
DETROIT BROACH & MACHINE CO., ROCHESTER, MICH.
DEUTSCH COMPANY, BANNING, CALIF.
DEUTSCH COMPANY, LOS ANGELES, CALIF.
DIAMOND ALKALI COMPANY, PAYNESVILLE, OHIO
DIAMOND, TOOLS & ABRASIVES INC., JUPITER, FLA.
DIAMONITE PRODUCTS MANUFACTURING CO., SHREVE, OHIO
D-K PRODUCTS (DIV. SYMINGTON WAYNE CORP.),
CHICAGO, ILL.
D-M-E CORPORATION, DETROIT, MICH.
DOALL COMPANY, DES PLAINES, ILL.
DOALL COMPANY, CINCINNATI, OHIO
DOVER CORPORATION, LOUISVILLE, KY.
DOVER CORPORATION, CINCINNATI, OHIO
DOW CHEMICAL COMPANY (THE), DENVER, COLO.
DOW CHEMICAL COMPANY (THE), GOLDEN, COLO.
DOW CHEMICAL COMPANY (THE), MIDLAND, MICH.
DREW CHEMICAL CORPORATION, BOONTON, N.J.
DREXEL INSTITUTE OF TECHNOLOGY, PHILADELPHIA, PA.
DUMORE COMPANY, RACINE, WISC.
DUNCAN MANUFACTURING CO., CINCINNATI OHIO
DUPOUNT DENEMOURS & CO. INC., E. I., WILMINGTON, DEL.
DUPOUNT DENEMOURS & CO. INC., E. I., POMPTON LAKE, N.J.
DUPOUNT DENEMOURS & CO. INC., E. I., MARTINSVILLE, VA.
DURIRON COMPANY, INC., DAYTON, OHIO
DYNA-EMPIRE, INC., LONG ISLAND, N.Y.
DYNA-TECH INC., DECATUR, ALA.
DYNAMICS CORP., OF AMERICA, GARDEN CITY, N.Y.

EAM INC., SKIPPAN, PA.
EAGLE TOOL & MACHINE COMPANY, SPRINGFIELD, OHIO

EASTERN KENTUCKY UNIVERSITY, RICHMOND, KY.
EASTERN KODAK COMPANY, RUTHERFORD, N.Y.
EATON YALE & TOWNE INC., SAGINAW, MICH.
EATON YALE & TOWNE INC., SOUTH EUCLID, OHIO
ECIVRES INC., NORWOOD, OHIO
EDMUNDS MANUFACTURING CO., FARMINGTON, CONN.
EIS AUTOMOTIVE CORPORATION (THE), MIDDLETOWN, CONN.
EITEL-MCCULLOUGH INC., SAN CARLOS, CALIF.
ELANO CORPORATION, XENIA, OHIO
ELASTIC STOP-NUT CORP. OF AMERICA, UNION, N.J.
ELECTRIC STORAGE BATTERY COMPANY (THE),
PHILADELPHIA, PA.
ELECTRICAL MACHINING INC., CINCINNATI, OHIO
ELECTRO-JET TOOL COMPANY, CINCINNATI, OHIO
ELECTRO-METHODS, INC., SOUTH WINDSOR, CONN.
ELECTROFILM, INC., NORTH HOLLYWOOD, CALIF.
ELECTRONIC SPECIALTY COMPANY, PORTLAND, ORE.
ELLIOTT COMPANY, JEANNETTE, PA.
ELOX CORP. OF MICHIGAN, TROY, MICH.
EMBOSOGRAPH DISPLAY MFG., CO., CHICAGO, ILL.
EMERSON ELECTRIC COMPANY, LOS ANGELES, CALIF.
EMERSON ELECTRIC COMPANY, ST. LOUIS, MO.
EMI, CINCINNATI, OHIO
ENGINEERING SOCIETIES LIBRARY, NEW YORK, N.Y.
ENGIS EQUIPMENT CO., MORTON GROVE, ILL.
ENTWISTLE MANUFACTURING CO., PROVIDENCE, R.I.
ERIE INDUSTRIES INC., FERNDALE, MICH.
ERNST, HANS, CLEARWATER, FLA.
ESARBE MANUFACTURING CO. INC., FT. LAUDERDALE, FLA.
ESCO CORPORATION, LOS ANGELES, CALIF.
ESSO RESEARCH & ENGINEERING CO., LINDEN, N.J.
EUCLID MACHINE CO., INC., INDIANAPOLIS, IND.
EX-CELL-O CORPORATION, LIMA, OHIO

FAFNIR BEARING COMPANY (THE), NEW BRITAIN, CONN.
FAIRCHILD HILLER CORPORATION, ROCKVILLE, MD.
FAIRCHILD HILLER CORPORATION, FARMINGDALE, L.I., N.Y.
FAIRCHILD PRECISION METALS PRODUCTS, EL CAJON, CALIF.
FANSTEEL METALLURGICAL CORP., NO. CHICAGO, ILL.
FEDERAL MOGUL CORP., DETROIT, MICH.
FELLOWS GEAR SHAPER COMPANY (THE), SPRINGFIELD, VT.
FERGUSON MACHINE COMPANY, TOLEDO, OHIO
FERRIS STATE COLLEGE, BIG RAPIDS, MICH.
FERROTHERM CO., CLEVELAND, OHIO
FIBEREX COMPANY, CLEVELAND, OHIO
FIBERITE CORPORATION, WINONA, WISC.
FIRESTONE TIRE & RUBBER CO. (THE), AKRON, OHIO
FIREWEL COMPANY INC. (THE), BUFFALO, N.Y.
FISCHER GOVERNOR COMPANY, MARSHALLTOWN, IOWA
FLICK-REEDY CORPORATION, BENSENVILLE, IND.
FMC CORPORATION, SAN JOSE, CALIF.
FMC CORPORATION, SANTA CLARA, CALIF.
FORD MOTOR COMPANY, DEARBORN, MICH.
FORD MOTOR COMPANY, METAL STAMPING, DEARBORN, MICH.
FORD MOTOR COMPANY, LIVONIA, MICH.
FORD MOTOR COMPANY, FAIRFAX PLANT, CINCINNATI, OHIO
FORD MOTOR COMPANY, SHARONVILLE PLANT, CINCINNATI,
OHIO
FORTNER ENGINEERING & MFG., INC., GLENDALE, CALIF.
FRANKFORD ARSENAL, PHILADELPHIA, PA.
FRANKLIN BALMAR CORPORATION, BALTIMORE, MD.
FRANKLIN ELECTRIC CO., INC., BLUFFTON, IND.
FRANKLIN OIL CORPORATION, BEDFORD, OHIO
PRECON ENGINEERING, CINCINNATI, OHIO
FULLER MERRIAM COMPANY, WEST HAVEN, CONN.
FYR-FYTER COMPANY (THE), NEWARK, N.J.

G & O TOOL & DIE COMPANY, BEECHGROVE, IND.
GALM COMPANY, KENNETH J., INDIANAPOLIS, IND.
GARDNER MACHINE COMPANY, SOUTH BELOIT, ILL.
GAR-KENYON INSTRUMENTS INC., BREWSTER, N.Y.

GEARCRAFT, INC., HAZEL PARK, MICH.
GEBEL INDUSTRIES, CINCINNATI, OHIO
GENERAL DYNAMICS CORP., POMONA, CALIF.
GENERAL DYNAMICS CORP., SAN DIEGO, CALIF.
GENERAL DYNAMICS CORP., GROTON, CONN.
GENERAL DYNAMICS CORP., NEW YORK, N.Y.
GENEPAL DYNAMICS CORP., FT. WORTH, TEX.
GENERAL ELECTRIC COMPANY, PHOENIX, ARIZ.
GENERAL ELECTRIC COMPANY, PLEASANTOWN, CALIF.
GENERAL ELECTRIC COMPANY, SAN JOSE, CALIF.
GENERAL ELECTRIC COMPANY, SUNNYVALE, CALIF.
GENERAL ELECTRIC COMPANY, DAYTONA BEACH, FLA.
GENERAL ELECTRIC COMPANY, BLOOMINGTON, ILL.
GENERAL ELECTRIC COMPANY, FT. WAYNE, IND.
GENERAL ELECTRIC COMPANY, LOUISVILLE, KY.
GENERAL ELECTRIC COMPANY, EVERETT, MASS.
GENERAL ELECTRIC COMPANY, LYNN, MASS.
GENERAL ELECTRIC COMPANY, DETROIT, MICH.
GENERAL ELECTRIC COMPANY, OAK PARK, MICH.
GENERAL ELECTRIC COMPANY, WARREN, MICH.
GENERAL ELECTRIC COMPANY, SOMERSWORTH, N.H.
GENERAL ELECTRIC COMPANY, KAPL, SCHENECTADY, N.Y.
GENERAL ELECTRIC COMPANY, SCHENECTADY, N.Y.
GENERAL ELECTRIC COMPANY, SYRACUSE, N.Y.
GENERAL ELECTRIC COMPANY, UTICA, N.Y.
GENERAL ELECTRIC COMPANY, WATERFORD, N.Y.
GENERAL ELECTRIC COMPANY, CINCINNATI, OHIO
GENERAL ELECTRIC COMPANY, CLEVELAND, OHIO
GENERAL ELECTRIC COMPANY, DAYTON, OHIO
GENERAL ELECTRIC COMPANY, ERIE, PA.
GENERAL ELECTRIC COMPANY, KING OF PRUSSIA, PA.
GENERAL ELECTRIC COMPANY, PHILADELPHIA, PA.
GENERAL ELECTRIC COMPANY, VALLEY FORGE SPACE
TECHNOLOGY CENTER, PHILADELPHIA, PA.
GENERAL ELECTRIC COMPANY, BURLINGTON, VT.
GENERAL ELECTRIC COMPANY, RUTLAND, VT.
GENERAL ELECTRIC COMPANY, WAYNESBORO, VA.
GENERAL ELECTRIC COMPANY, MILWAUKEE, WISC.
GENERAL ELECTRO-MECH CORP., BUFFALO, N.Y.
GENERAL MANUFACTURING CORP., LODI, N.J.
GENERAL MOTORS CORPORATION, INDIANAPOLIS, IND.
GENERAL MOTORS CORPORATION, MUNCIE, IND.
GENERAL MOTORS CORPORATION, LANSING, MICH.
GENERAL MOTORS CORPORATION, WARREN, MICH.
GENERAL MOTORS CORPORATION, HARRISON, N.J.
GENERAL MOTORS CORPORATION, MILWAUKEE, WISC.
GENERAL MOTORS CORPORATION, DEFENSE RESEARCH LAB.,
SANTA BARBARA, CALIF.
GENERAL MOTORS CORPORATION, DELCO REMY DIVISION,
ANDERSON, IND.
GENERAL MOTORS CORPORATION, FRIGIDAIRE DIVISION,
DAYTON, OHIO
GENERAL MOTORS CORPORATION, GUIDE LAMP DIVISION,
ANDERSON, IND.
GENERAL MOTORS CORPORATION, INLAND MANUFACTURING,
DAYTON, OHIO
GENERAL MOTORS INSTITUTE, FLINT, MICH.
GENERAL PRECISION AEROSPACE TECHNICAL INFORMATION
CENTER, LITTLE FALLS, N.J.
GENERAL PRECISION INCORPORATED, BINGHAMTON, N.Y.
GENERAL PRECISION INCORPORATED, PLEASANTVILLE, N.Y.
GENERAL TRANSDUCER COMPANY, SANTA CLARA, CALIF.
GEOMETRIC TOOL COMPANY, NEW HAVEN, CONN.
GEORGE'S SCREW PRODUCTS, FRANKLIN PARK, ILL.
GISHOLT CORPORATION, MADISON, WISC.
GLIDDEN COMPANY (THE), BALTIMORE, MD.
GODDARD SPACE FLIGHT CENTER, GREENBELT, MICH.
GOODRICH COMPANY, B. F., AKRON, OHIO
GOODYEAR AEROSPACE CORPORATION, AKRON, OHIO

GOULD'S PUMPS INC., SENECA FALLS, N.Y.
GRAHAM RESEARCH LABORATORY, PITTSBURGH, PA.
GRAND VALLEY STATE COLLEGE, ALLENDALE, MICH.
GRAY, CONWAY, G. A., CINCINNATI, OHIO
GREAT LAKES RESEARCH CORPORATION, ELIZABETHTON, TENN.
GREAT LAKES STEEL CORPORATION, DETROIT, MICH.
GREENFIELD TAP & DIE, GREENFIELD, MASS.
GREENLEAF CORPORATION, HAGERSTOWN, PA.
GRIFFIN WHEEL COMPANY, CHICAGO, ILL.
GRIKO CHEMICAL PRODUCTS INC., NEWARK, N.J.
GRISWOLD-ESHLERMAN COMPANY (THE), CLEVELAND, OHIO
GRUMMAN AIRCRAFT ENGINEERING CORP., GLENARM, MD.
GRUMMAN AIRCRAFT ENGINEERING CORP., BETHPAGE, L.I., N.Y.
GULF COAST TECHNICAL INSTITUTE, GULFPORT, MISS.
GULF GENERAL ATOMIC INC., SAN DIEGO, CALIF.
H & C SUPPLY CORPORATION, ROCHESTER, N.Y.
HALL PLANETARY CO. OF PHILADELPHIA, PHILADELPHIA, PA.
HAMILTON STANDARD, WINDSOR LOCKS, CONN.
HAMILTON TOOL & MACHINE CO., KENILWORTH, N.J.
HARNISCHFEGER COMPANY, ESCANABA, MICH.
HARNISCHFEGER COMPANY, MILWAUKEE, WISC.
HARRELL HOLMES MARKETING, CINCINNATI, OHIO
HARRIS-INTERTYPE CORPORATION, CLEVELAND, OHIO
HARRISON MANUFACTURING CO., TEMPE, ARIZ.
HARVARD BUSINESS SCHOOL, CAMBRIDGE, MASS.
HARVEY ALUMINUM SALES INC., EAST ORANGE, N.J.
HASTINGS MANUFACTURING CO., HASTINGS, MICH.
HATER INDUSTRIES, CINCINNATI, OHIO
HAYES-ALBION CORPORATION, HILLSDALE, MICH.
HAYES, MAX S. VOCATIONAL HIGH SCHOOL, CLEVELAND, OHIO
HEALD MACHINE COMPANY, WORCESTER, MASS.
HENDRIKSEN, ERIK, DOWNEY, CALIF.
HERCULES INC., ALLEGANY BALLISTICS LAB., CUMBERLAND, MD.
HERKERT PRODUCTS COMPANY, CHICAGO, ILL.
HESSTON CORPORATION, HESSTON, KAN.
HEWLETT-PACKARD CO., PALO ALTO, CALIF.
HILL, GEORGE M., OXFORD, OHIO
HINKLE BROTHERS INC., CLARKSBURG, W. VA.
HIRSMANN CORPORATION, ROSLYN HEIGHTS, N.Y.
HITTMAN ASSOCIATES, INC., COLUMBIA, MD.
HOBART MANUFACTURING COMPANY, TROY, OHIO
HOFFMAN BROTHERS JEWELRY CO., TUNKSUTANNEY, PA.
HOKE INC., CRESSKILL, N.J.
HOLLEY CARBURETOR COMPANY, CLARE, MICH.
HOLLEY CARBURETOR COMPANY, WARREN, MICH.
HOLYOKE MACHINE COMPANY, HOLYOKE, MASS.
HONEYWELL INC., ST. PETERSBURG, FLA.
HONEYWELL, INC., HOPKINS, MINN.
HONEYWELL INC., NEW BRIGHTON, MINN.
HONEYWELL INC., MINNEAPOLIS, MINN.
HOUGHTON COMPANY, E. F., CINCINNATI, OHIO
HOUGHTON COMPANY, E. F., CLEVELAND, OHIO
HOUSTON, UNIVERSITY OF, HOUSTON, TEX.
HUCKTROL INC., KINGSTON, N.Y.
HUGHES AIRCRAFT COMPANY, TUCSON, ARIZ.
HUGHES AIRCRAFT COMPANY, CULVER CITY, CALIF.
HUGHES AIRCRAFT COMPANY, EL SEGUNDO, CALIF.
HUGHES AIRCRAFT COMPANY, LOS ANGELES, CALIF.
HUGHES TOOL COMPANY, CULVER CITY, CALIF.
HUMBLE OIL & REFINING CO., HOUSTON, TEX.
HUYCK METALS COMPANY, MILFORD, CONN.
HYDRAULIC RESEARCH & MANUFACTURING CO.,
BURBANK, CALIF.
HYDRODYNE ENGINEERING COMPANY, SANTA ANA, CALIF.
HYSTER COMPANY, DANVILLE, ILL.
HYSTER COMPANY, PORTLAND, ORE.
ITT RESEARCH INSTITUTE, CHICAGO, ILL.
ITT CANNON ELECTRIC INC., LOS ANGELES, CALIF.

ITT-GILFILLAN, VAN NUYS, CALIF.
 ILLINOIS, STATE OF, SPRINGFIELD, ILL.
 ILLINOIS TOOL WORKS, INC., ELGIN, ILL.
 ILLINOIS, UNIVERSITY OF, URBANA, ILL.
 INDUSTRIAL NUCLEONICS CORP., COLUMBUS, OHIO
 INDUSTRIAL PRESS, INC., NEW YORK, N.Y.
 INDUSTRIAL TOOL & MACHINE CO., GEORGIAVILLE, R.I.
 INDUSTRIAL TECTONICS, INC., COMPTON, CALIF.
 INGERSOLL MILLING MACHINE CO. (THE), ROCKFORD, ILL.
 INGERSOLL RAND COMPANY, PHILIPSBURG, N.J.
 INGERSOLL RAND COMPANY, PRINCETON, N.J.
 INGERSOLL RAND COMPANY, PAINTED POST, N.Y.
 INSTITUTE OF GAS TECHNOLOGY, CHICAGO, ILL.
 INTERNATIONAL BUSINESS MACHINES CORP.,
 LEXINGTON, KY.
 INTERNATIONAL BUSINESS MACHINES CORP., ROCKVILLE, MD.
 INTERNATIONAL BUSINESS MACHINES CORP., ENDICOTT, N.Y.
 INTERNATIONAL BUSINESS MACHINES CORP., KINGSTON, N.Y.
 INTERNATIONAL BUSINESS MACHINES CORP., OWEKO, N.Y.
 INTERNATIONAL BUSINESS MACHINES CORP., POUGHKEEPSIE,
 N.Y.
 INTERNATIONAL BUSINESS MACHINES CORP., YORKTOWN HEIGHTS,
 N.Y.
 INTERNATIONAL BUSINESS MACHINES CORP., DAYTON, OHIO
 INTERNATIONAL GLASS COMPANY, NEW YORK, N.Y.
 INTERNATIONAL HARVESTER COMPANY, SAN DIEGO, CALIF.
 INTERNATIONAL HARVESTER COMPANY, CHICAGO, ILL.
 INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION INC.,
 NEW YORK, N.Y.
 INTERNATIONAL NICKEL CO., INC. (THE), NEW YORK, N.Y.
 INTERNATIONAL NICKEL CO., INC. (THE), SUFFERN, N.Y.
 INTERNATIONAL NICKEL CO., INC. (THE), DAYTON, OHIO
 INTERNATIONAL NICKEL CO., INC. (THE), HUNTINGTON, W. VA.
 ION PHYSICS CORPORATION, BURLINGTON, MASS.
 IOWA STATE UNIVERSITY OF SCIENCE & TECHNOLOGY,
 AMES, IOWA
 IOWA, UNIVERSITY OF, IOWA CITY, IOWA
 IRON AGE, PHILADELPHIA, PA.
 ITEK CORPORATION, LEXINGTON, MASS.
 JACKUP BOAT BUILDERS, INC., BRAITHWAITE, LA.
 JANITROL AERO, COLUMBUS, OHIO
 JANSSEN MANUFACTURING COMPANY, WAYNESVILLE, OHIO.
 JARVIS CORPORATION, PORTLAND, CONN.
 JARVIS CORPORATION, GREENWOOD, S.C.
 JERDEN MANUFACTURING COMPANY, INDIANAPOLIS, IND.
 JET PRODUCTS CORPORATION, SAN DIEGO, CALIF.
 JOHNSON, BILL SUPPLY CO., PHOENIX, ARIZ.
 JOINT VOCATIONAL SCHOOL, SPRINGFIELD, OHIO
 JOMICO METAL FABRICATION, ST. LOUIS, MO.
 JONES & LAMSON, SPRINGFIELD, VT.
 JONES & LAUGHLIN STEEL CORP., INDIANAPOLIS, IND.
 JORDON VALVE, CINCINNATI, OHIO
 KDI COMPANY, CINCINNATI, OHIO
 KAISER AEROSPACE & ELECTRONICS, SAN LEANDRO, CALIF.
 KAMIA MANUFACTURING CO., GRAND RAPIDS, MICH.
 KANSAS STATE COLLEGE OF PITTSBURGH, PITTSBURGH, KAN.
 KARL & SONS, WILLIAM, MIDDLE VILLAGE, N.Y.
 KEARNEY & CO., INC., A.T., CHICAGO, ILL.
 KEARNEY & TRECKER, MILWAUKEE, WISC.
 KEMETRIC COMPANY, SUNNYVALE, CALIF.
 KEMPER INSURANCE CO., NEW YORK, N.Y.
 KENNAMETAL INC., CINCINNATI, OHIO
 KENNAMETAL INC., BEDFORD, PA.
 KENNAMETAL INC., LATROBE, PA.
 KENNEDY SPACE CENTER, KENNEDY SPACE CENTER, FLA.
 KENT STATE UNIVERSITY, KENT, OHIO
 KERIS MANUFACTURING CO., LONG ISLAND CITY, N.Y.
 KING FIFTH WHEEL COMPANY, MOUNTAINTOP, PA.
 KINSEY, COMPANY, E. A., CINCINNATI, OHIO
 KLIK INDUSTRIES, HARTFORD, CONN.
 KLINE MANUFACTURING CO., WESTERVILLE, OHIO
 KNOX ATOMIC POWER LAB., NISKAYUNA, N.Y.
 KOBE INC., HUNTINGTON PARK, CALIF.
 KOE-RING CO., HPM DIVISION, MT. GILEAD, OHIO
 KOPPERS COMPANY INC., BALTIMORE, MD.
 KREISLER INDUSTRIAL CORP., EAST PATTERSON, N.J.
 KRESS CORPORATION, CLEVELAND, OHIO
 KRONENBERG, DR. MAX, CINCINNATI, OHIO
 KUNTZ COMPANY, J. R., DAYTON, OHIO
 LADISH COMPANY, CULAHY, WISC.
 LANCASTER METAL PRODUCTS, LANCASTER, OHIO
 LASALLE STEEL COMPANY, CHICAGO, ILL.
 LASALLE STEEL COMPANY, HAMMOND, IND.
 LATROBE STEEL COMPANY, LATROBE, PA.
 LAVALLE & IDE INC., CHICAGO, MASS.
 LAVIN & SONS, INC., R, CHICAGO, ILL.
 LAWRENCE AVIATION INDUSTRIES, INC., NEW YORK, N.Y.
 LAWRENCE RADIATION LABORATORY, LIVERMORE, CALIF.
 LEAR SIEGLER COMPANY, GRAND RAPIDS, MICH.
 LEBANON STEEL FOUNDRY, LEBANON, PA.
 LEBLOND MACHINE TOOL COMPANY, R. K., CINCINNATI, OHIO
 LEHIGH UNIVERSITY, BETHLEHEM, PA.
 LELAND-GIFFORD COMPANY, WORCESTER, MASS.
 LENNOR ENGINEERING COMPANY, CHICAGO, ILL.
 LESSELLS AND ASSOCIATES, WALTHAM, MASS.
 LDR TOOL COMPANY, PROVIDENCE, R.I.
 LINAIR ENGINEERING, DANIA, FLA.
 LING-TEMCO-VOUGHT, INC., DALLAS, TEX.
 LING-TEMCO-VOUGHT (LTV AEROSPACE), WARREN, MICH.
 LING-TEMCO-VOUGHT (LTV ELECTROSYSTEMS),
 GREENVILLE, TEX.
 LINK BELT COMPANY, INDIANAPOLIS, IND.
 LINK BELT COMPANY, PHILADELPHIA, PA.
 LIQUID DYNAMICS, CHICAGO, ILL.
 LITTLE CO., INC., ARTHUR D., CAMBRIDGE, MASS.
 LITWIN COMPANY, CINCINNATI, OHIO
 LLOYD PRODUCTS COMPANY, CINCINNATI, OHIO
 LOCKHEED AIRCRAFT CORPORATION, BURBANK, CALIF.
 LOCKHEED AIRCRAFT CORPORATION, PALO ALTO, CALIF.
 LOCKHEED AIRCRAFT CORPORATION, REDLANDS, CALIF.
 LOCKHEED AIRCRAFT CORPORATION, SUNNYVALE, CALIF.
 LOCKHEED-GEORGIA COMPANY, MARIETTA, GA.
 LODGE & SHIPLEY COMPANY (THE), CINCINNATI, OHIO
 LONGYEAR COMPANY, E. J., MINNEAPOLIS, MINN.
 LORD MANUFACTURING COMPANY, ERIE, PA.
 LOUD COMPANY, H. W., POMONA, CALIF.
 LUBRI PRODUCTS INC., NORTH ATTLEBORO, MASS.
 LUNKENHEIMER COMPANY, CINCINNATI, OHIO
 MS&R INC., IRWIN, PA.
 MACHINE DESIGN, CLEVELAND, OHIO
 MACHINECRAFT, INC., BALTIMORE, MD.
 MACHINERY, WHEATON, ILL.
 MACHINERY, BIRMINGHAM, MICH.
 MACHINERY SALES COMPANY, LOS ANGELES, ILL.
 MACHINING TECHNOLOGY CORPORATION, SO. WINDSOR, CONN.
 MACKLIN COMPANY, JACKSON, MICH.
 MADISON INDUSTRIES, PROVIDENCE, R.I.
 MAFFITT TOOL & MACHINE COMPANY, ST. LOUIS, MO.
 MAGNA MACHINE COMPANY, CINCINNATI, OHIO
 MALLEABLE FOUNDERS SOCIETY, CLEVELAND, OHIO
 MANHATTAN RAYBESTOE COMPANY, CORINTH, KY.
 MANSFIELD PHOTO ENGRAVING, MANSFIELD, OHIO
 MAREMONT COMPANY, SACO, ME.
 MARLIN-ROCKWELL COMPANY, PLAINVILLE, CONN.
 MARQUARDT CORPORATION (THE), VAN NUYS, CALIF.
 MARQUARDT CORPORATION (THE), OGDEN, UTAH
 MARQUETTE METAL PRODUCTS CO., CLEVELAND, OHIO

MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALA.
 MARTIN COMPANY, DENVER, COLO.
 MARTIN COMPANY, ORLANDO, FLA.
 MARTIN COMPANY, BALTIMORE, MD.
 MARTIN COMPANY, WHEELING, ILL.
 MASSACHUSETTS INSTITUTE OF TECHNOLOGY,
 CAMBRIDGE, MASS.
 MASSET-FERGUSON INC., DETROIT, MICH.
 MASTER CHEMICAL CORPORATION, PERRYSBURG, OHIO
 MASTER MANUFACTURING CO., INC., HUTCHINSON, KAN.
 MATERIALS DEVELOPMENT INC., PROSPECT, KY.
 MATERIALS IN DESIGN ENGINEERING, NEW YORK, N.Y.
 MATERIALS TESTING LABORATORY, LOS ANGELES, CALIF.
 MAYNARD & COMPANY, INC., H.B., PITTSBURGH, PA.
 MCCLELLAN AIR FORCE BASE, SACRAMENTO, CALIF.
 McCULLOCH CORPORATION, LOS ANGELES, CALIF.
 McDONNELL DOUGLAS CORP., HUNTINGTON BEACH, CALIF.
 McDONNELL DOUGLAS CORP., LONG BEACH, CALIF.
 McDONNELL DOUGLAS CORP., SANTA MONICA, CALIF.
 McGRAW-EDISON COMPANY, COLUMBUS, OHIO
 McGRAW-EDISON COMPANY, PITTSBURGH, PA.
 McGRAW-EDISON COMPANY, SO. MILWAUKEE, WISC.
 McGREGOR MANUFACTURING CORP., TROY, MICH.
 MCKINNEY INC., HARRIS D., PHILADELPHIA, PA.
 MCMLLON BROTHERS, INC., STRATFORD, CONN.
 MEAD CORPORATION, CINCINNATI, OHIO
 MEASUREGRAPH COMPANY, ST. LOUIS, MO.
 MECHANICAL SPECIALTIES, INC., LOS ANGELES, CALIF.
 MECHANICAL SUPPLIES COMPANY, CINCINNATI, OHIO
 MEDICO INDUSTRIES, INC., WILKES BARRE, PA.
 MELPAR INC., FALLS CHURCH, VA.
 MEMCOR INC., HUNTINGTON, IND.
 MENASCO MANUFACTURING COMPANY, BURBANK, CALIF.
 MENASCO MANUFACTURING COMPANY, FT. WORTH, TEX.
 MERCER ALLOYS CORPORATION, GREENVILLE, PA.
 MERCER MACHINE COMPANY, INDIANAPOLIS, IND.
 METAL FINISHING SERVICE, CHICAGO, ILL.
 METAL LUBRICANTS COMPANY, CHICAGO, ILL.
 METAL POWDER INDUSTRIES FEDERATION, NEW YORK, N.Y.
 METAL-MATION INC., SOUTH BEND, IND.
 METALORE, EL SEGUNDO, CALIF.
 METALWORKING MAGAZINE, BOSTON, MASS.
 METALWORKING NEWS, CINCINNATI, OHIO
 METCUT RESEARCH ASSOCIATES INC., CINCINNATI, OHIO
 METEM CORPORATION, HANOVER, N.J.
 MICHIGAN ABRASIVE COMPANY, DETROIT, MICH.
 MICHIGAN TECHNOLOGY UNIVERSITY, HOUGHTON, MICH.
 MICHIGAN TOOL COMPANY, DETROIT, MICH.
 MICHIGAN STATE UNIVERSITY, EAST LANSING, MICH.
 MICHIGAN UNIVERSITY, CENTRAL, MT. PLEASANT, MICH.
 MICHIGAN UNIVERSITY, EASTERN, YPSILANTI, MICH.
 MICHIGAN UNIVERSITY, NORTHERN, MARQUETTE, MICH.
 MICHIGAN, UNIVERSITY OF, ANN ARBOR, MICH.
 MIDDLE COUNTRY CENTRAL SCHOOL DISTRICT 11,
 CENTEREACH, N.Y.
 MIDDLETOWN HIGH SCHOOL, MIDDLETOWN, OHIO
 MIDWEST RESEARCH INSTITUTE, KANSAS CITY, MO.
 MIDWEST TECHNICAL SERVICES, INC., CINCINNATI, OHIO
 MILLER, L. C. COMPANY, MONTEREY PARK, CALIF.
 MILLERS FALLS COMPANY, CINCINNATI, OHIO
 MILWAUKEE GEAR COMPANY, MILWAUKEE, WISC.
 MINIATURE PRECISION BEARINGS, INC., KEENE, N.H.
 MINNESOTA MINING & MANUFACTURING CO., ST. PAUL, MINN.
 MODERN MACHINE SHOP, CINCINNATI, OHIO
 MOHAWK TOOLS, INC., MONTPELIER, OHIO
 MONITOR BOXART CORP., FARMINGDALE, L.I., N.Y.
 MONSANTO RESEARCH CORPORATION, HARTFORD, CONN.
 MONSANTO RESEARCH CORPORATION, DAYTON, OHIO
 MONSANTO RESEARCH CORPORATION, MIAMISBURG, OHIO
 MONTGOMERY CO., H. A., DETROIT, MICH.
 MONTGOMERY ELEVATOR COMPANY, MOLINE, ILL.
 MOOG, INC., EAST AURORA, N.Y.
 MOREHEAD STATE UNIVERSITY, MOREHEAD, KY.
 MORFORM TOOL COMPANY, CINCINNATI, OHIO
 MORGEN DESIGN, INC., CINCINNATI, OHIO
 MORRIS & COMPANY, E. K., CINCINNATI, OHIO
 MORRIS MACHINE CO., INC., INDIANAPOLIS, IND.
 MORSE TWIST DRILL & MACHINE CO., CHICAGO, ILL.
 MORWEAR TOOLS INC., CINCINNATI, OHIO
 MOSLER LOCK COMPANY, MILFORD, OHIO
 MOTION INDICATING DEVICES, INC., BUFFALO, N.Y.
 MOTOROLA INC., SCOTTSDALE, ARIZ.
 MUSKEGON TOOL INDUSTRIES INC., MUSKEGON, MICH.
 NASA, HUNTSVILLE, ALA.
 NASA, MOFFETT FIELD, CALIF.
 NASA, SCIENTIFIC & TECHNOLOGY INFORMATION FACILITY,
 BETHESDA, Md.
 NASA, LANGLEY RESEARCH CENTER, HAMPTON, VA.
 NASA, LEWIS RESEARCH CENTER, CLEVELAND, OHIO
 NATIONAL BERYLLIA CORPORATION, HASKELL, N.J.
 NATIONAL BUREAU OF STANDARDS, BOULDER, COLO.
 NATIONAL CASH REGISTER COMPANY, DAYTON, OHIO
 NATIONAL FORGE COMPANY, IRVINE, WARREN COUNTY, PA.
 NATIONAL LEAD COMPANY OF OHIO, CINCINNATI, OHIO
 NATIONAL LEAD COMPANY OF OHIO, FERNALD, OHIO
 NATIONAL SCREW MACHINE PRODUCTS ASSOCIATION,
 CLEVELAND, OHIO
 NATIONAL WATER LIFT COMPANY, KALAMAZOO, MICH.
 NAVAL AIR ENGINEERING CENTER, PHILADELPHIA, PA.
 NAVAL AIR REWORK FACILITIES, SAN DIEGO, CALIF.
 NAVAL RESEARCH OFFICE OF, WASHINGTON, D.C.
 NELCO CUTTER COMPANY, MANCHESTER, CONN.
 NEUMAN & COMPANY, H., SKOKIE, ILL.
 NEVILL, C. R., INDIANAPOLIS, IND.
 NEW BRITAIN MACHINE CO. (THE), NEW BRITAIN, CONN.
 NEW ENGLAND METALLURGICAL CORPORATION, S. BOSTON, MASS.
 NEW ENGLAND RESEARCH APPLICATION CENTER, STOORRS, CONN.
 NEW HAMPSHIRE BALL BEARINGS, INC., PETERBOROUGH, N.H.
 NEW YORK STATE UNIVERSITY OF BINGHAMTON,
 BINGHAMTON, N.Y.
 NOBLE INC., NORMAN, CLEVELAND, OHIO
 NOLTE SCREW MACHINE, CINCINNATI, OHIO
 NORDEN COMPANY, NORWALK, CONN.
 NORTH AMERICAN ROCKWELL CORP., ANAHEIM, CALIF.
 NORTH AMERICAN ROCKWELL CORP., CANOGA PARK, CALIF.
 NORTH AMERICAN ROCKWELL CORP., EL SEGUNDO, CALIF.
 NORTH AMERICAN ROCKWELL CORP., INGLEWOOD, CALIF.
 NORTH AMERICAN ROCKWELL CORP., LOS ANGELES, CALIF.
 NORTH AMERICAN ROCKWELL CORP., NEGSHO, MO.
 NORTH AMERICAN ROCKWELL CORP., COLUMBUS, OHIO
 NORTH AMERICAN ROCKWELL CORP., TULSA, OKLA.
 NORTH CAROLINA STATE UNIVERSITY, RALEIGH, N.C.
 NORTH HARTFORD HIGH SCHOOL, PYLESVILLE, MD.
 NORTHEAST CUTTER SERVICE CORP., FARMINGDALE, N.Y.
 NORTHEASTERN UNIVERSITY, BOSTON, MASS.
 NORTHMONT SCHOOL, CLAYTON, OHIO
 NORTHRUP NORAIR, HAWTHORNE, CALIF.
 NORTHRUP VENTURA, NEWBURY PARK, CALIF.
 NORTON COMPANY, WORCESTER, MASS.
 NRC EQUIPMENT CORPORATION, NEWTON, MASS.
 NUCLEAR METALS, INC., WEST CONCORD, MASS.
 NUMERICAL CONTROL & COMPUTER SERVICES, CLEVELAND, OHIO
 NJ-TEC ENGINEERING CORPORATION, WARREN, MICH.
 NU-TOOL SAW SERVICE, INC., DETROIT, MICH.
 OK TOOL COMPANY, MILFORD, N.H.
 OAKES CORPORATION, E. T., LONG ISLAND, N.Y.
 OBERG MANUFACTURING COMPANY, INC., FREEPORT, PA.
 OHIO COLLEGE OF APPLIED SCIENCE, CINCINNATI, OHIO
 OHIO SCREW PRODUCTS, INC., ELYRIA, OHIO
 OHIO STATE UNIVERSITY (THE), COLUMBUS, OHIO

OKLAHOMA STATE UNIVERSITY, STILLWATER, OKLA.
 OLIN DIXON CORPORATION, COFFEEVILLE, KAN.
 OLIVER MACHINERY COMPANY, GRAND RAPIDS, MICH.
 ONSRUD MACHINE WORKS, NILES, ILL.
 ONTARIO CORPORATION, MUNCIE, INC.
 OREGON TECHNICAL INSTITUTE, KLAMATH FALLS, ORE.
 OTIS ELEVATOR COMPANY, YOUNKERS, N.Y.
 OWENS-ILLINOIS, INC., COLUMBUS, OHIO
 OWENS-ILLINOIS, TOLEDO, OHIO

PACIFIC SCIENTIFIC COMPANY, ANAHEIM, CALIF.
 PACKER CONSULTING ASSOCIATES, NAPERVILLE, ILL.
 PANDA PRODUCTS, CINCINNATI, OHIO
 PAYER, E. L. COMPANY, WENONAH, N.J.
 P. E. DEVELOPMENT COMPANY, CINCINNATI, OHIO
 PEABODY INDUSTRIES, PEABODY, MASS.
 PECK, PAUL H., BROCKTON, MASS.
 PENN NUCLEAR CORPORATION, PENN, PA.
 PENNSYLVANIA STATE UNIVERSITY, UNIVERSITY PARK, PA.
 PENTA TECHNICAL COLLEGE, PERRYSBURG, OHIO
 PERKIN-ELMER CORP., DANBURY, CONN.
 PESCO PRODUCTS, BEDFORD, OHIO
 PHELPS-DODGE-COPPER PRODUCTS CORP., ELIZABETH, N.J.
 PHILADELPHIA NAVAL SHIPYARD, PHILADELPHIA, PA.
 PHILCO CORPORATION, LAWNDALE, CALIF.
 PHILCO CORPORATION, NEWPORT BEACH, CALIF.
 PICATINNY ARSENAL, DOVER, N.J.
 PIFER INDUSTRIES, INC., DURHAM, N.C.
 PIONEER ASTRO INDUSTRIES INC., HARWOOD HEIGHTS, ILL.
 PIONEER BROACH COMPANY, LOS ANGELES, CALIF.
 PIPE MACHINERY COMPANY, CLEVELAND, OHIO
 PITTSBURGH PLATE GLASS CO., PITTSBURGH, PA.
 PLANET PRODUCTS CORPORATION, CINCINNATI, OHIO
 PLASTIC MOLDINGS CORP., CINCINNATI, OHIO
 POINT PARK COLLEGE, PITTSBURGH, PA.
 POLYMET CORPORATION, CINCINNATI, OHIO
 PRATT & WHITNEY AIRCRAFT, EAST HARTFORD, CONN.
 PRATT & WHITNEY AIRCRAFT, NORTH HAVEN, CONN.
 PRATT & WHITNEY AIRCRAFT, WEST PALM BEACH, FLA.
 PRATT & WHITNEY CORPORATION, CUDAHY, CALIF.
 PRATT & WHITNEY CORPORATION, W. HARTFORD, CONN.
 PRECISION CASTPARTS CORP., PORTLAND, ORE.
 PRECISION MACHINE & TOOL, INC., VANDALIA, OHIO
 PRECISION MECHANICS INC., CINCINNATI, OHIO
 PRESTOLITE COMPANY (THE), DECATUR, ALA.
 PRISOCK ASSOCIATES, JOHN, CINCINNATI, OHIO
 PROCTER & GAMBLE COMPANY, CINCINNATI, OHIO
 PRUYNE COMPANY, SAN DIEGO, CALIF.
 PUBLIC HEALTH SERVICE, BETHESDA, MD.
 PURDUE UNIVERSITY, WEST LAFAYETTE, IND.
 PUREX CORPORATION LTD., ANAHEIM, CALIF.

QUAKER CHEMICAL CORPORATION, CONSHOHOCKEN, PA.

RGF CORPORATION, ELWOOD, IND.
 RADIO CORPORATION OF AMERICA, INDIANAPOLIS, IND.
 RADIO CORPORATION OF AMERICA, CAMDEN, N.J.
 RADIO CORPORATION OF AMERICA, PRINCETON, N.J.
 RADIO CORPORATION OF AMERICA, LANCASTER, PA.
 RADIO ENGINEERING LABORATORIES, LONG ISLAND, N.Y.
 RAYTHEON COMPANY, WALTHAM, MASS.
 RAYTHEON COMPANY, WAYLAND, MASS.
 RAYTHEON COMPANY, BRISTOL, TENN.
 REACTIVE METALS, INC., NILES, OHIO
 REDSTONE ARSENAL, U.S. ARMY MISSILE COMMAND,
 REDSTONE ARSENAL, ALA.
 REEDER & KLINE MACHINE CO., INC., CARMEL, IND.
 REGENTS OF THE UNIVERSITY SYSTEM OF GEORGIA,
 ATLANTA, GA.
 RELIANCE ELECTRIC COMPANY, ASHTABULA, OHIO

RESOURCES DEVELOPMENT CORPORATION, EAST LANSING, MICH.
 REX CHAINBELT, INC., DOWNSERS GROVE, ILL.
 REX CHAINBELT, INC., MILWAUKEE, WISC.
 REYNOLDS METALS COMPANY, RICHMOND, VA.
 RHODE ISLAND, UNIVERSITY OF, KINGSTON, R.I.
 RIDINGS, JAMES A., PITTSBURG, KAN.
 ROCK ISLAND ARSENAL, ROCK ISLAND, ILL.
 ROHR CORPORATION, CHULA VISTA, CALIF.
 ROLLWAY BEARING COMPANY, SYRACUSE, N.Y.
 ROMA CORPORATION, INDIANAPOLIS, IND.
 ROOTS-CONNERSVILLE, BLOWER DIV., CONNERSVILLE, IND.
 ROYAL OAK TOOL COMPANY, ROYAL OAK, MICH.
 RUST-LICK INC., BOSTON, MASS.
 RYAN AERONAUTICAL COMPANY, SAN DIEGO, CALIF.
 RYERSON & SON, INC., JOSEPH T., CHICAGO, ILL.
 RYERSON & SON, JOSEPH T., CINCINNATI, OHIO

S & R TOOL CORPORATION, DAYTON, OHIO
 S&S MACHINERY COMPANY, BROOKLYN, N.Y.
 SAE STEELS, INC., HUDSON, OHIO
 SCM CORPORATION, ORANGEBURG, S.C.
 SKF INDUSTRIES, TIMONIUM, MD.
 SAGINAW VALLEY COLLEGE, UNIV. CENTER, MICH.
 SAN FRANCISCO CITY COLLEGE, SAN FRANCISCO, CALIF.
 SAN JOSE STATE COLLEGE, SAN JOSE, CALIF.
 SANDERS ASSOCIATES, NASHUA, N.H.
 SANDERS NUCLEAR CORP., NASHUA, N.H.
 SANDIA CORPORATION, ALBUQUERQUE, N.M.
 SATEC CORPORATION, GROVE CITY, PA.
 SAUNDERS & CO. INC., ALEXANDER, COLD SPRING, N.Y.
 SCHELLENS TRUE CORPORATION, IVORYTON, CONN.
 SCHUTTE AND KOERTING COMPANY, BUCKS COUNTY, PA.
 SEATTLE UNIVERSITY, SEATTLE, WASH.
 SEIFREAT-ELSTAD MACHINERY CO., CINCINNATI, OHIO
 SENCO PRODUCTS, NEWTON, OHIO
 SETCO INDUSTRIES INC., CINCINNATI, OHIO
 SEYBOLD COMPANY, CINCINNATI, OHIO
 SHAPE COMPONENTS, INC., PATTERSON, N.J.
 SHEAFFER PEN COMPANY, W. A., FT. MADISON, IOWA
 SHEFFER CORPORATION (THE), CINCINNATI, OHIO
 SHEFFIELD CORPORATION (THE), DAYTON, OHIO
 SHAYYDER CHEMICAL METALLURGY CORP., DETROIT, MICH.
 SIGMA MACHINERY, ROSEMONT, ILL.
 SIKORSKY AIRCRAFT, STRATFORD, CONN.
 SILTRONICS INC., OAKMONT, PA.
 SIMOND SAW & STEEL, FITCHBURG, MASS.
 SINCLAIR REFINING COMPANY, CHICAGO, ILL.
 SINCLAIR REFINING COMPANY, COLUMBUS, OHIO
 SMALL BUSINESS ADMIN., DENVER, COLOR.
 SMALL BUSINESS ADMIN., CHICAGO, ILL.
 SMALL BUSINESS ADMIN., MINNEAPOLIS, MINN.
 SMALL BUSINESS ADMIN., CLEVELAND, OHIO
 SMALL BUSINESS ADMIN., BALA CYWYD, PA.
 SMALL BUSINESS ADMIN., SEATTLE, WASH.
 SMITH, C. W. ENGINEERING CO., INC., MADISON
 HEIGHTS, MICH.
 SNAP-ON-TOOLS COMPANY, KENOSHA, WISC.
 SONNET TOOL & MFG. CO., HAWTHORNE, CALIF.
 SOUTH CHESTER CORPORATION, LESTER, PA.
 SOUTH SHORE TOOL & DEVELOPMENT INC., MENTOR, OHIO
 SOUTHERN AUTOMATICS INC., CINCINNATI, OHIO
 SOUTHERN ILLINOIS UNIVERSITY, CARBONDALE, ILL.
 SOUTHERN RESEARCH INSTITUTE, BIRMINGHAM, ALA.
 SOUTHWEST RESEARCH INSTITUTE, SAN ANTONIO, TEX.
 SOUTHWESTERN CITY SCHOOL, GROVE CITY, OHIO
 SOUTHWORTH MACHINE COMPANY, PORTLAND, ME.
 SPECIAL MACHINE COMPANY, ROCKFORD, ILL.
 SPERRY RAND CORPORATION, PHOENIX, ARIZ.
 SPERRY RAND CORPORATION, CLEARWATER, FLA.

SPERRY RAND CORPORATION, DETROIT, MICH.
 SPERRY RAND CORPORATION, JACKSON, MISS.
 SPERRY RAND CORPORATION, TROY, MICH.
 SPERRY RAND CORPORATION, GREAT NECK, N.Y.
 SPERRY RAND CORPORATION, LONG ISLAND CITY, N.Y.
 SPERRY RAND CORPORATION, BRISTOL, TENN.
 SPERRY RAND CORPORATION, SALT LAKE CITY, UTAH
 SPINDLETOP RESEARCH, LEXINGTON, KY.
 SPRINGFIELD ARMORY, SPRINGFIELD, MASS.
 ST. JOSEPH LEAD COMPANY, MONACA, PA.
 STANDARD OIL CO., CHICAGO, ILL.
 STANDARD OIL CO., - OHIO (THE), CINCINNATI, OHIO
 STANDARD OIL CO., - OHIO (THE), CLEVELAND, OHIO
 STANDARD PRESSED STEEL CO., JENKINTOWN, PA.
 STARK INDUSTRIAL SUPPLY COMPANY, CANTON, OHIO
 STATE OF MICHIGAN, EAST LANSING, MICH.
 STATHAM INSTRUMENTS, OXNARD, CALIF.
 STEEL MAGAZINE, CLEVELAND, OHIO
 STERLING FAUCET COMPANY, MORGANTOWN, W. VA.
 STERLING GRINDING WHEEL CO., TIFFIN, OHIO
 STERLING INSTRUMENT, MINEOLA, N.Y.
 STEVENS INSTITUTE OF TECHNOLOGY, HOBOKEN, N.J.
 STRASMAN MACHINERY CORPORATION, LONG BEACH, CALIF.
 STUART OIL CO., LTD., D. A., CHICAGO, ILL.
 STUDERAKER CORPORATION, DUNBAR, W. VA.
 STYRE/PAK, NEWTON, IOWA
 SUN OIL COMPANY, CINCINNATI, OHIO
 SUN OIL COMPANY, MARCUS Hook, PA.
 SUN SHIPBUILDING & DRY DOCK CO., CHESTER, PA.
 SUNDSTRAND CORPORATION, SYRACUSE, N.Y.
 SUNDSTRAND CORPORATION, SUNDSTRAND AVIATION,
 ROCKFORD, ILL.
 SUNDSTRAND CORPORATION, SUNDSTRAND MACHINE TOOL CO.,
 BELVIDERE, ILL.
 SYLVANIA ELECTRIC PRODUCTS, INC., SALEM, MASS.
 SYLVANIA ELECTRIC PRODUCTS, INC., WALTHAM, MASS.
 SYLVANIA HIGH SCHOOL, SWANTON, OHIO
 SYLVESTRE SCREW COMPANY, PROVIDENCE, R. I.
 SYSTEMS RESEARCH LABS., DAYTON, OHIO
 TRW, INC., CLEVELAND, OHIO
 TRW, INC., PORT CLINTON, OHIO
 TRW, INC., DANVILLE, PA.
 TRW, INC., HARRISBURG, PA.
 TRW, INC., LEBANON, TENN.
 TAFT ENGINEERING CENTER, CINCINNATI, OHIO
 TAYLOR FORGE INC., CHICAGO, ILL.
 TECHNICAL CONSULTANTS INC., HUNTINGTON, W. VA.
 TECHNICAL EQUIPMENT SALES CO., CINCINNATI, OHIO
 TECHNICAL PROGRAMMING ASSOC., INC., SMYRA, GA.
 TECHNICAL & TRADE TRAINING CENTER, WESTBURY, N.Y.
 TECHNOLOGY REPORTS, CHESTERLAND, OHIO
 TECUMSEH PRODUCTS COMPANY, ANN ARBOR, MICH.
 TELEDYNE COMPANY, BROWN ENRG. CO., HUNTSVILLE,
 ALA.
 TELEDYNE INC., WAH CHANG, GLEN COVE, N.Y.
 TELEDYNE INC., ALLVAC METALS, MONROE, N.C.
 TELEDYNE COMPANY, CINCINNATI, OHIO
 TELEDYNE INC., FIRTH STERLING, PITTSBURGH, PA.
 TELEDYNE INC., VASCO, LATROBE, PA.
 TELEDYNE INC., AUTOMATED SPECIALTIES,
 CHARLOTTESVILLE, VA.
 TELEFLEX INC., NORTH WALES, PA.
 TELETYME CORPORATION, SKOKIE, ILL.
 TENNESSEE, UNIVERSITY OF, KNOXVILLE, TENN.
 TEXACO INC., BEACON, N.Y.
 TEXACO INC., CINCINNATI, OHIO
 TEXAS INSTRUMENTS INC., DALLAS, TEX.
 TEXAS, UNIVERSITY OF, AUSTIN, TEX.
 THERM INC., ITHACA, N.Y.

THIOKOL CHEMICAL CORP., DENVILLE, N.J.
 THOMPSON COMPANY, JOHN I., WASHINGTON, D.C.
 TIBBETTS INDUSTRIES, INC., CAMDEN, ME.
 TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO
 TINKER AIR FORCE BASE, OKLAHOMA CITY, OKLA.
 TIPP MACHINE & TOOL INC., TIPP CITY, OHIO
 TIPPETT INCORPORATED, CHICOPEE FALLS, MASS.
 TITANIUM METALS CORPORATION OF AMERICA,
 NEW YORK, N.Y.
 TITANIUM METALS CORPORATION OF AMERICA,
 TORONTO, OHIO
 TOOL SALES & SERVICE, CINCINNATI, OHIO
 TOOL STEEL GEAR & PINION CO. (THE), CINCINNATI, OHIO
 TOULON HIGH SCHOOL, TOULON, ILL.
 TOWNSEND COMPANY, SANTA ANA, CALIF.
 TRAUB STROHM CORPORATION, PLAINVIEW, N.Y.
 TRI INDUSTRIES INC., TERRE HAUTE, IND.
 TRI-D CORPORATION, PLAINVILLE, CONN.
 TRITON COLLEGE, PHILADELPHIA, PA.
 TROYAN-KENNEDY COMPANY, CINCINNATI, OHIO
 TRU-CUT INC., ATLANTA, GA.
 TRU-CUT MACHINE CORPORATION, CINCINNATI, OHIO
 TWIN CITY, ARSENAL, NEW BRIGHTON, MINN.
 TYCO LABORATORIES, WALTHAM, MASS.
 TYLER CORPORATION, BENSON, MINN.
 UTD CORPORATION, ATHOL, MASS.
 UTD CORPORATION, DERBY LINE, VT.
 U.S. AIR FORCE, APO, N.Y.
 U.S. ARMY, EDGEWOOD ARSENAL, EDGEWOOD, ARSENAL, MD.
 U.S. ARMY, PRODUCTION ENGINEERING DIVISION,
 FT. BELVIEV, VA.
 U.S. ARMY, PRODUCTION EQUIPMENT AGENCY,
 ROCK ISLAND, ILL.
 U.S. ARMY, WEAPONS COMMAND, ROCK ISLAND, ILL.
 U.S. ATOMIC ENERGY COMMISSION, WASHINGTON, D.C.
 U.S. BAIRD CORPORATION, STRATFORD, CONN.
 U.S. DEFENSE SUPPLY AGENCY, CINCINNATI, OHIO
 U.S. DEPARTMENT OF COMMERCE, WASHINGTON, D.C.
 U.S. DEPARTMENT OF DEFENSE, N. ARLINGTON, VA.
 U.S. DEPARTMENT OF THE INTERIOR, ROLLA, MO.
 U.S. DEPARTMENT OF JUSTICE, WASHINGTON, D.C.
 U.S. MARINE CORPS., CHERRY POINT, N.C.
 U.S. MISSILE CENTER, MUGU, CALIF.
 U.S. NAVAL APPLIED SCIENCE LAB., BROOKLYN, N.Y.
 U.S. NAVAL AVIONICS FACILITY, DEPARTMENT OF
 NAVY, INDIANAPOLIS, INC.
 U.S. NAVAL ORDNANCE LAB., WHITE OAK, MD.
 U.S. NAVAL ORDNANCE TEST STATION, CHINA
 LAKE, CALIF.
 U.S. NAVAL POST GRADUATE SCHOOL, MONTEREY, CALIF.
 U.S. NAVAL UNDERWATER ORDNANCE STATION,
 NEWPORT, R.I.
 U.S. NAVY, WASHINGTON, D.C.
 U.S. STEEL CORPORATION, MONROEVILLE, PA.
 UNIMET CARBIDES, DIV. OF UNITED GREENFIELD,
 CHICAGO, ILL.
 UNION CARBIDE CORPORATION, INDIANAPOLIS, IND.
 UNION CARBIDE CORPORATION, KOKOMO, IND.
 UNION CARBIDE CORPORATION, PADUCAH, KY.
 UNION CARBIDE CORPORATION, TARRYTOWN, N.Y.
 UNION CARBIDE CORPORATION, OAK RIDGE NATIONAL
 LAB, OAK RIDGE, TENN.
 UNION CARBIDE CORPORATION, Y12 PLANT, OAK
 RIDGE, TENN.
 UNITED AIRCRAFT CORPORATE SYSTEMS CENTER,
 FARMINGTON, CONN.
 UNITED AIRCRAFT PRODUCTS, INC., FOREST, OHIO
 UNITED AIR LINES, SAN FRANCISCO, CALIF.
 UNITED NUCLEAR CORP., NEW HAVEN, CONN.

UNITED SHOE MFG., CORP., (THE), BEVERLY, MASS.
UNITED STATES BORAX & CHEMICAL CORP., NEW YORK, N.Y.
UNITED STATES LIAISON OFFICE, APO, N.Y.
UNITED STATES TIME CORPORATION, WATERBURY, CONN.
UNITED TECHNOLOGY CENTER, SUNNYVALE, CALIF.
UNIVAC, ROSEVILLE, MINN.
UNIVAC, SALT LAKE CITY, UTAH
UNIVERSAL-CYCLOPS SPECIALTY STEEL, BRIDGEVILLE, PA.
UNIVERSAL TECHNOLOGY CORP., DAYTON, OHIO
UNIVERSAL VALVE COMPANY, INC., ELIZABETH, N.J.
UTAH STATE UNIVERSITY, LOGAN, UTAH
UTAH, UNIVERSITY OF, SALT LAKE CITY, UTAH

V.I. JEWELRY MANUFACTURING CORP., NEW YORK, N.Y.
VALERON CORPORATION (THE), LOS ANGELES, CALIF.
VALERON CORPORATION (THE), INDIANAPOLIS, IND.
VALERON CORPORATION (THE), DAYTON, OHIO
VALUE PROGRAM FOR INDUSTRY, SCHENECTADY, N.Y.
VAN INDUSTRIES, CINCINNATI, OHIO
VAN STRAATEN CHEMICAL COMPANY, CHICAGO, ILL.
VARIAN ASSOCIATES, PALO ALTO, CALIF.
VARO INC., SANTA BARBARA, CALIF.
VEEDER-ROOT INC., ALTOONA, PA.
VERMONT AMERICAN CORPORATION, LOUISVILLE, KY.
VIKING FORGE & STEEL COMPANY, ALBANY, CALIF.
VINCO CORPORATION, DETROIT, MICH.
VIRGINIA POLYTECHNIC INSTITUTE, BLACKSBURG, VA.
VITRO CORPORATION OF AMERICA, WEST ORANGE, N.J.
VITRO LABORATORIES, SILVER SPRINGS, MD.
VOGT MACHINE CO. INC., HENRY, LOUISVILLE, KY.
VR/WESSON COMPANY, CINCINNATI, OHIO

WALKER COMPANY, O.S., WORCESTER, MASS.
WALKER GRINDING COMPANY, SANTA BARBARA, CALIF.
WALMET CORPORATION (THE), PLEASANT RIDGE, MICH.
WALMET CORPORATION (THE), SUMMITT, N.J.
WALTCO ENGINEERING COMPANY, GARDENA, CALIF.
WARNER-SWASEY COMPANY (THE), CLEVELAND, OHIO
WARNER-SWASEY COMPANY (THE), LAHR DIVISION,
CLEVELAND, OHIO
WARREN PUMPS, INC., WARREN, MISS.
WATERTOWN ARSENAL, WATERTOWN, MASS.
WATERVLIET ARSENAL, WATERVLIET, N.Y.
WAUKESHA CUTTING TOOL, WAUKESHA, WISC.
WAYNE STATE UNIVERSITY, DETROIT, MICH.
WEATHERHEAD COMPANY (THE), DAYTON, OHIO
WEBCO MACHINE PRODUCTS, INC., CLEVELAND, OHIO
WEINMAN PUMP MANUFACTURING CO. (THE), COLUMBUS, OHIO
WEST MILTON PRECISION TOOL CO., VANDALIA, OHIO
WEST VIRGINIA, STATE OF, DEPARTMENT OF COMMERCE,
CHARLESTON, W. VA.
WESTERN ELECTRIC COMPANY, INC., OMAHA, NEB.
WESTERN ELECTRIC COMPANY, INC., GREENSBORO, N.C.
WESTERN ELECTRIC COMPANY, INC., PRINCETON, N.J.
WESTERN ELECTRIC COMPANY, INC., NEW YORK, N.Y.
WESTERN GEAR CORPORATION, EVERETT, WASH.
WESTERN MICHIGAN UNIVERSITY, KALAMAZOO, MICH.
WESTERN RESERVE UNIVERSITY, CLEVELAND, OHIO
WESTINGHOUSE AIR BRAKE COMPANY, PEORIA, ILL.
WESTINGHOUSE ELECTRIC CORP., SUNNYVALE, CALIF.
WESTINGHOUSE ELECTRIC CORP., BUFFALO, N.Y.
WESTINGHOUSE ELECTRIC CORP., CHARLOTTE, N.C.
WESTINGHOUSE ELECTRIC CORP., BLAIRSVILLE, PA.
WESTINGHOUSE ELECTRIC CORP., HOMWOOD, PA.
WESTINGHOUSE ELECTRIC CORP., MADISON, PA.
WESTINGHOUSE ELECTRIC CORP., PHILADELPHIA, PA.
WESTINGHOUSE ELECTRIC CORP., PITTSBURGH, PA.

WESTINGHOUSE ELECTRIC CORP., WEST MIFFLIN, PA.
WHEELABRATOR CORPORATION, MISHAWAKA, INC.
WHITE COUNTY MACHINE SHOP, MONTICELLO, INC.
WHITIN MACHINE WORKS, WHITINSVILLE, MASS.
WHITTAKER CORPORATION, LA MESA, CALIF.
WHITTAKER CORPORATION, WEST CONCORD, MASS.
WILLIAMS RESEARCH & ENGINEERING CO., WALLED
LAKE, MICH.
WINDSOR MANUFACTURING, WINDSOR, CONN.
WISCONSIN STATE UNIVERSITY, PLATTEVILLE, WISC.
WISCONSIN, UNIVERSITY, MADISON, WISC.
WITHROW COMPANY, ARTHUR C., LOS ANGELES, CALIF.
WOLVERINE BRASS WORKS, GRAND RAPIDS, MICH.
WORLD AEROSPACE CORP., MINNEAPOLIS, MINN.
WORLD TOOL & ENGINEERING CO., MINNEAPOLIS, MINN.
WRIGHT-PATTERSON AIR FORCE BASE, FABRICATION
MODIFICATION SHOP, WRIGHT-PATTERSON AFB, OHIO
WRIGHT-PATTERSON AIR FORCE BASE, FOREIGN DISCLOSURE
OFFICE, WRIGHT-PATTERSON AFB, OHIO
WRIGHT-PATTERSON AIR FORCE BASE, FOREIGN TECHNOLOGY
OFFICE, WRIGHT-PATTERSON AFB, OHIO
WRIGHT-PATTERSON AIR FORCE BASE, MANUFACTURING
TECHNOLOGY DIVISION, WRIGHT-PATTERSON AFB, OHIO
WYMAN-GORDON COMPANY, NORTH GRAFTON, MASS.
WYMAN-GORDON COMPANY, WORCESTER, MASS.

XEROX CORPORATION, ROCHESTER, N.Y.

ZENITH MANUFACTURING COMPANY, OAK PARK, MICH.
ZIMNEY CORPORATION, MONROVIA, CALIF.

NEW COMPANIES & AGENCIES SUBMITTING INQUIRIES TO AFMDC

OCTOBER 1, 1968 - JULY 31, 1969

ASC CORPORATION, OWINGS MILLS, MD.
ABEX CORPORATION, COLUMBUS, OHIO
ACTION MANUFACTURING COMPANY, PHILADELPHIA, PA.
ADJUSTABLE BUSHING CORPORATION, NORTH HOLLYWOOD, CALIF.
ADMIRAL MACHINE COMPANY, BARBERTON, OHIO
AERO PRECISION MACHINING CORP., FRANKLIN PARK, ILL.
AFFILIATED N/C SERVICES, INC., WICHITA, KAN.
AIR FORCE, DEPARTMENT OF THE, LOS ANGELES, CALIF.
AIR FORCE, DEPARTMENT OF THE, VANDENBERG AFB, CALIF.
AIR FORCE, DEPARTMENT OF THE, STRATFORD, CONN.
AIRCO, BERKELEY, CALIF.
ALCAN ALUMINUM CORPORATION, RIVERSIDE, CALIF.
ALCOA ALUMINUM COMPANY OF AMERICA, CLEVELAND, OHIO
ALCOA ALUMINUM COMPANY OF AMERICA, LANCASTER, PA.
ALLBRIGHT-NEIL CO., THE, CHICAGO, ILL.
ALLEGHENY-LUDLUM STEEL CORP., BRACKENRIDGE, PA.
ALLEGHENY-LUDLUM STEEL CORP., LEECHBURG, PA.
AMBAC INDUSTRIES, LONG ISLAND, N.Y.
AMERICAN INSTITUTE RESEARCH, PITTSBURGH, PA.
AMFORGE INCORPORATED, CHICAGO, ILL.
ANDERSON, GORDON S., MFG. CO., MILLBROOK, N.J.
ANDERSON, INC., CHICAGO, ILL.
ANDREWS MACHINE WORKS, COVINGTON, KY.
ARISTA TECHNICAL SERVICE, NEWARK, N.J.
ARIZONA FIRE RATING BUREAU, PHOENIX, ARIZ.
ARMY MATERIALS & MECH. RESEARCH CENTER, WATERTOWN, MASS.
ARMY, DEPARTMENT OF THE, WARREN, MICH.
AUBURN UNIVERSITY, AUBURN, ALA.
AUSTIN CONTINENTAL INDUSTRIES, INC., CHICAGO, ILL.
AUTOCLOVE ENGINEERS, INC., ERIE, PA.
AVCO CORPORATION, LOWELL, MASS.
AVCO CORPORATION, CINCINNATI, OHIO

BABCOCK & WILCOX COMPANY, BARBERTON, OHIO
BAUER BROTHERS COMPANY, SPRINGFIELD, OHIO
BEALE AIR FORCE BASE, BEALE AFB, CALIF.
BELL AEROSYSTEMS, BUFFALO, N.Y.
BENDIX CORPORATION, THE, EATON TOWN, N.J.
BENDIX CORPORATION, THE, UTICA, N.Y.
BENDIX CORPORATION, THE, DAYTON, OHIO
BERLIN SUPPLY COMPANY, PHILADELPHIA, PA.
BINNS MACHINERY PRODUCTS, CINCINNATI, OHIO
BLADES MANUFACTURING CORP., RECTOR, ARK.
BODINE ELECTRIC COMPANY, CHICAGO, ILL.
BOLTON-EMERSON, INC., LAWRENCE, MASS.
BOWER ROLLER BEARING COMPANY, DETROIT, MICH.
BOYLAN COMPANY, P.O., CINCINNATI, OHIO
BRIDGEPORT MACHINES INCORPORATED, BRIDGEPORT, CONN.
BROOKHAVEN NATIONAL LAB., LONG ISLAND, N.Y.
BROWDER INDUSTRIES INC., DAYTON, OHIO
BUEHLER CORPORATION, THE, INDIANAPOLIS, IND.
BUNKER-RAMO CORPORATION, THE, HIGHLAND HEIGHT, OHIO
BURLINGTON INDUSTRIES, GREENBROOK, N.C.

C-E-I-R INCORPORATED, WASHINGTON, D.C.
CANN & SAUL STEEL COMPANY, ROYERSFORD, PA.
CARLSON, G.O. INC., THORNDALE, PA.
CARMET COMPANY, FERNDALE, MICH.
CARNEGIE-MELLON UNIVERSITY, PITTSBURGH, PA.
CESSNA AIRCRAFT COMPANY, HUTCHINSON, KAN.
CHEM TECH RESEARCH CORP., MEDWAY, MASS.
CHROME PLATE INC., SAN ANTONIO, TEX.
CHRYSLER CORPORATION, DETROIT, MICH.
CINCINNATI GEAR COMPANY, THE, CINCINNATI, OHIO
CINCINNATI SUPERIOR PRODUCTS COMPANY, CINCINNATI, OHIO
CINEX ENGINEERING, CINCINNATI, OHIO
CIRCUITS, TEMPE, ARIZ.
CLFCO INDUSTRIAL TOOLS, HOUSTON, TEX.
CLEVELAND STATE UNIVERSITY, CLEVELAND, OHIO
CONNECTICUT EDUCATIONAL TELEVISION, INC., HARTFORD, CONN.
CONTINENTAL CONSULTANTS, INC., DAYTON, OHIO
CONTROL DATA CORPORATION, MINNEAPOLIS, MINN.
CONTROL DATA CORPORATION, OMAHA, NEB.

COOPER INDUSTRIES, INC., MT. VERNON, OHIO
COURTER TECHNICAL HIGH SCHOOL, CINCINNATI, OHIO
CRAFTS, ARTHUR A. CORPORATION, WALTHAM, MASS.
CRUCIBLE STEEL COMPANY, SYRACUSE, N.Y.

DAVEY COMPRESSOR COMPANY, KENT, OHIO
DAYTON SUPPLY & TOOL CO., THE, DAYTON, OHIO
DEFENSE CONTRACT ADM. SERVICES DISTRICT, PHOENIX, ARIZ.
DELPHI CORPORATION, DAYTON, OHIO
DIAL MACHINE COMPANY, LEVITTOWN, PA.
DIAMOND MACHINE WORKS, SEATTLE, WASHINGTON
DIER, GEORGE H. COMPANY, CINCINNATI, OHIO
DO-RITE TOOL & MFG. COMPANY, MINNEAPOLIS, MINN.

EVANSVILLE, UNIVERSITY OF, EVANSVILLE, IND.

FMC CORPORATION, INDIANAPOLIS, IND.
FALK CORPORATION, THE, MILWAUKEE, WISC.
FEDERAL CARTRIDGE, ST. PAUL, MINN.
FORMMET CORPORATION, AVON, OHIO
FOSDICK MACHINE TOOL CO., CINCINNATI, OHIO
FRANKLIN INSTITUTE RESEARCH LAB, THE, PHILADELPHIA, PA.

GENERAL AMERICAN RESEARCH, NILES, ILL.
GENERAL DYNAMICS CORP., AVENEL, N.J.
GENERAL ELECTRIC COMPANY, JONESBORO, ARK.
GENERAL ELECTRIC COMPANY, SPRINGFIELD, MASS.
GENERAL ELECTRIC COMPANY, ALBUQUERQUE, N.M.
GENERAL ELECTRIC COMPANY, WORCESTER, MASS.
GENERAL ELECTRIC COMPANY, GREENVILLE, S.C.
GENERAL-GILBERT CORP., WINSTED, CONN.
GENERAL MOTORS CORPORATION, LA GRANGE, ILL.
GRACE, W.R. COMPANY, CLARKSVILLE, MD.
GRACE, W.R. COMPANY, CINCINNATI, OHIO
G. W. PLASTICS ENGINEERING, BETHEL, VT.

H & H INDUSTRIES, DAYTON, OHIO
HAUSER RESEARCH & ENGINEERING CO., BOULDER, COLO.
HAWAII TECHNOLOGICAL INFORMATION CENTER, HONOLULU, HAWAII
HAYES-ALBION CORPORATION, ALBION, MICH.
HECKER, A.W. COMPANY, CLEVELAND, OHIO
HEYNE, ROY L. MACHINE CO., PHOENIX, ARIZ.
HOEGANAE CORPORATION, RIVERTON, N.J.
HOFFERBERTH MACHINERY CO., DAYTON, OHIO
HORSBURGH & SCOTT CO., THE, CLEVELAND, OHIO
HOWE RICHARDSON SCALE CO., RUTLAND, VT.
HOWMET CORPORATION, POMONA, CALIF.
H. R. SUPPLY COMPANY, CINCINNATI, OHIO
HUGHES AIRCRAFT COMPANY, CANOGA PARK, CALIF.
HUGHES AIRCRAFT COMPANY, MALIBU, CALIF.
HUMBLE OIL & REFINING COMPANY, CHARLOTTE, N.C.
HUMBLE OIL & REFINING COMPANY, BALA CYNWYD, PA.
HUMBLE OIL & REFINING COMPANY, PITTSBURGH, PA.
HUMBLE OIL & REFINING COMPANY, SAEGERTOWN, PA.

IBM CORPORATION, SAN JOSE, CALIF.
IBM CORPORATION, ARMONK, N.Y.
IBM CORPORATION, CINCINNATI, OHIO
IMPLANT RESEARCH CORPORATION, PENNSAUKEN, N.J.
INDIANA, UNIVERSITY OF, BLOOMINGTON, IND.
INFORMATION INDUSTRIES, INC., SILVER SPRING, MD.
INGERSOLL MILLING MACHINE CO., ROCKFORD, ILL.
INTERNATIONAL REFINING AND MFG., CO., EVANSTON, ILL.
INTERNATIONAL RESEARCH & MARKETING, NEW YORK, N.Y.
INTERNATIONAL RESEARCH CONSULTANTS, SOUTHFIELD, MICH.
INVINCIBLE GEAR COMPANY, DETROIT, MICH.

JERPBAK-BAYLESS COMPANY, SOLON, OHIO
JOSTENS INC., OWATONNA, MINN.

KAISER ALUMINUM & CHEMICAL CORP., NEWARK, OHIO

KAISER ALUMINUM & CHEMICAL CORP., SPOKANE, WASH.
 KAN-WAY MFG., COMPANY INC., VALLEY STREAM, N.Y.
 KANSAS, UNIVERSITY OF, LAWRENCE, KAN.
 KAPPELL, LOH C., YELLOW SPRINGS, OHIO
 KELLY AIR FORCE BASE, SAN ANTONIO, TEX.
 KENNAMETAL INC., INDIANAPOLIS, IND.
 KERNS UNITED, CALUMET CITY, ILL.
 KEYES-DAVIS COMPANY, THE, BATTLE CREEK, MICH.
 LAKEWOOD MANUFACTURING COMPANY, WESTLAKE, OHIO
 LA PINESE MACHINE TOOL COMPANY, HUDSON, MASS.
 LEAR SIEGLER, INC., ZEELAND, MICH.
 LEBLOND DISTRICT SALES OFFICE, R.K.,
 CINCINNATI, OHIO
 LIBRARY OF CONGRESS, WASHINGTON, D.C.
 LITTON INDUSTRIES, INC., BEVERLY HILLS, CALIF.
 LITTON INDUSTRIES, INC., WASHINGTON, D.C.
 LUCAS MACHINE, CLEVELAND, OHIO
 MACHINE PRODUCTS COMPANY, LOVELAND, OHIO
 MAINE, UNIVERSITY OF, PORTLAND, ME.
 MALLORY, P.R. METALLURGICAL COMPANY,
 INDIANAPOLIS, IND.
 MARIAN COLLEGE, INDIANAPOLIS, IND.
 MASON & COMPANY, INC., NEWPORT NEWS, VA.
 MECHANICAL MANUFACTURING, INC., FARNINGTON, MICH.
 MECHANICAL TECHNOLOGY INC., LATHAM, N.Y.
 MELFRED WELDING & MFG., INC., LOS ANGELES, CALIF.
 MICROMATIC HONE CORPORATION, DETROIT, MICH.
 MICRO-SWISS, INC., CHERRY HILL, N.J.
 MIDWAY COMPANY, LODI, N.J.
 MINE SAFETY APPLIANCES COMPANY, PITTSBURGH, PA.
 MINNESOTA, UNIVERSITY OF, MINNEAPOLIS, MINN.
 MISSOURI, UNIVERSITY OF, CLAYTON, MO.
 MODERN PLASTICS ENCYCLOPEDIA, NEW YORK, N.Y.
 MODINE MFG., COMPANY, RACINE, WISC.
 MOTH AND MERRYWEATHER MACHINERY, CINCINNATI, OHIO
 NASA, SANDUSKY, OHIO
 NATIONAL AUTOMATIC TOOL CO., RICHMOND, IND.
 NATIONAL GAGE & DIE COMPANY, AGAWAM, MASS.
 NATIONAL JET SALES CORPORATION, LA VALE, MD.
 NAVY, DEPARTMENT OF THE, VALLEJO, CALIF.
 NEW BRITAIN MACHINE CO., THE, CLEVELAND, OHIO
 NEW YORK GEAR WORKS, LONG ISLAND, N.Y.
 NEW YORK, STATE UNIVERSITY OF, STONY BROOK, N.Y.
 NORBERG MANUFACTURING COMPANY, MILWAUKEE, WISC.
 NORTH AMERICAN PHILIPS CO., INC., BRIARCLIFF
 MANOR, N.Y.
 NORTH AMERICAN ROCKWELL CORP., DOWNEY, CALIF.
 NORTH AMERICAN ROCKWELL CORP., LONG BEACH, CALIF.
 NORTHEASTERN TOOL COMPANY, HAVERHILL, MASS.
 NORTHROP CORPORATION, ANAHEIM, CALIF.
 NORTON COMPANY, CINCINNATI, OHIO
 NUMERICAL CONTROL PROGRAM SERV. INC.,
 ABINGTON, PA.
 OWENS-ILLINOIS INC., PITTSBURGH, PA.
 OZONE METALS PRODUCTS CORP., OZONE PARK, N.Y.
 PACIFIC PUMPING COMPANY, OAKLAND, CALIF.
 PALMER ELECTRONICS INC., GARFIELD, N.J.
 PARSONS DIAMOND PRODUCTS, INC., WEST
 HARTFORD, CONN.
 PATKAY, STEPHEN & ASSOCIATES, PASADENA, CALIF.
 PENNSALT CHEMICALS CORP., KING OF PRUSSIA, PA.
 PIPER AIRCRAFT CORPORATION, VERO BEACH, FLA.
 PLAS-MET MANUFACTURING CORPORATION, BIDDEFORD, ME.
 PORTER-MCLEOD MACHINE TOOL CO., INC.,
 HATFIELD, MASS.

PORTER PRECISION PRODUCTS, CINCINNATI, OHIO
 PROSPECT TOOL & DIE CO., WOBURN, MASS.
 PUREX CORPORATION, LTD., WILMINGTON, CALIF.
 RACINE HYDRAULICS & MACHINERY, INC., RACINE, WISC.
 RAYTHEON COMPANY, ANDOVER, MASS.
 REASSELAER POLYTECHNIC INST., TROY, N.Y.
 REMINGTON ARMS COMPANY INC., ILION, N.Y.
 RENIER ENGINEERING & TOOL INC., DETROIT, MICH.
 ROCKWELL MANUFACTURING COMPANY, BARBERTON, OHIO
 ROCKWELL MANUFACTURING COMPANY, PITTSBURGH, PA.
 SKF INDUSTRIES, INC., MASSILION, OHIO
 SCHRADER AUTOMOTIVE PRODUCTS, DICKSON, TENN.
 SEALOL INC., PROVIDENCE, R.I.
 SCINSHEIMER, W.G. & ASSOC., CINCINNATI, OHIO
 SERVOMETER CORPORATION, CLIFTON, N.J.
 SIEKMANN, JACK, GROSSE POINT, MICH.
 SIMMONDS PRECISION PRODUCTS INC., VERGEMENNE, VT.
 SMALL BUSINESS ADMIN., SAN FRANCISCO, CALIF.
 SMALL BUSINESS ADMIN., WASHINGTON, D.C.
 SMALL BUSINESS ADMIN., BOSTON, MASS.
 SMALL BUSINESS ADMIN., DETROIT, MICH.
 SMALL BUSINESS ADMIN., NEW YORK, N.Y.
 SMALL BUSINESS ADMIN., DALLAS, TEX.
 SOUTH BEND LATHE, SOUTH BEND, IND.
 SOUTHERN CALIFORNIA, UNIVERSITY OF, LOS ANGELES,
 CALIF.
 SOUTHERN MINNESOTA STATE COLLEGE, MARSHALL, MINN.
 SPEEDRING CORPORATION, WARREN, MICH.
 SPERRY RAND CORPORATION, ST. PAUL, MINN.
 SPERRY RAND CORPORATION, BELLEVUE, PA.
 STANDARD PRESSED STEEL, JENKINTOWN, PA.
 STRAUCHEN & MCKIM ADVERTISING, CINCINNATI, OHIO
 STRESSKIN PRODUCTS COMPANY, SANTA ANA, CALIF.
 SYSTEMS TECHNOLOGY CORPORATION, DAYTON, OHIO
 TRW, REDONDO BEACH, CALIF.
 TAYLOR & COMPANY INC., DAYTON, OHIO
 TAYLOR-WHARTON COMPANY, NORWOOD, OHIO
 TECHNO TRUCK MFG., CO., CLEVELAND, OHIO
 TEXAS A & M UNIVERSITY, COLLEGE STATION, TEX.
 THERMO ELECTRON CORPORATION, WOBURN, MASS.
 THIKOL CHEMICAL CORPORATION, MARSHALL, TEX.
 TOLEDO, UNIVERSITY OF, TOLEDO, OHIO
 TOOL STEEL GEAR & PINION CO., CINCINNATI, OHIO
 TOOLMAN COMPANY, THE, PASADENA, CALIF.
 TOOLING AND PRODUCTION, CLEVELAND, OHIO
 TORRINGTON COMPANY, THE, TORRINGTON, CONN.
 TORRINGTON COMPANY, THE, UNION, S.C.
 TWIN DISC, INC., RACINE, WISC.
 UTD CORPORATION, FARMINGVILLE, N.Y.
 UTD CORPORATION, CINCINNATI, OHIO
 U.S. DEPARTMENT OF COMMERCE, WASHINGTON, D.C.
 U.S. NAVAL ORDNANCE LAB, SILVER SPRING, MD.
 U.S. ARMY - FORT DETRICK, FREDERICK, MD.
 U.S. STEEL CORPORATION, PITTSBURGH, PA.
 UNICHEM CORPORATION, WARREN, MICH.
 UNIDYNAMICS, ST. LOUIS, MO.
 UNION CARBIDE CORPORATION, NEW YORK, N.Y.
 UNION CARBIDE CORPORATION, PARMA, OHIO
 UNION MACHINE COMPANY, SAN FRANCISCO, CALIF.
 UNIONSON CORPORATION, MADISON HEIGHTS, MICH.
 UNITED GREENFIELD CORPORATION, ROGERS, ARK.
 UNITED ENGINEERING & MFG., STRATFORD, CONN.
 URBAN LEAGUE, CINCINNATI, OHIO
 VALUE ENGINEERING COMPANY, ALEXANDRIA, VA.
 VERMONT ART STUDIO, PITTSFORD, VT.

VERMONT PRECISION PRODUCTS, INC., BARTONSVILLE, VT.
VERMONT STRUCTURAL STEEL CORPORATION, BURLINGTON, VT.
VERMONT TAP & DIE COMPANY, LOUISVILLE, KY.
VERMONT, UNIVERSITY OF, BURLINGTON, VT.
VIRGINIA STATE TECHNICAL SERVICE, ARLINGTON, VA.
VULCAN - CINCINNATI, CINCINNATI, OHIO

WADELL EQUIPMENT COMPANY, INC., CLARK, N.J.
WAH CHANG ALBANY CORP., ALBANY, OREG.
WALKER MACHINERY COMPANY, CINCINNATI, OHIO
WEATHERHEAD COMPANY, SYRACUSE, INC.
WEMCO MANUFACTURING CORPORATION, COLORADO SPRINGS,
COLO.
WEST VIRGINIA UNIVERSITY, MORGANTOWN, W. VA.

WESTERN ELECTRIC COMPANY, INC., KEARNEY, N.J.
WESTERN ELECTRIC COMPANY, INC., SALEM, N.C.
WESTINGHOUSE ELECTRIC CORP., LIMA, OHIO
WESTINGHOUSE ELECTRIC CORP., DERBY, PA.
WHITNEY-KAPPES INC., CINCINNATI, OHIO
WHITTAKER CORPORATION, LOS ANGELES, CALIF.
WINONA TOOL MANUFACTURING COMPANY, WINONA, MINN.
WOODWARD GOVERNOR COMPANY, ROCKFORD, ILL.
WRIGHT, FRED D. CO., INC., NASHVILLE, TENN.
XOMOX CONTINENTAL MFG. CO., CINCINNATI, OHIO
YORDE MACHINE PRODUCTS COMPANY, NELSONVILLE, OHIO
ZARKIN MACHINE COMPANY, INC., LONG ISLAND, N.Y.

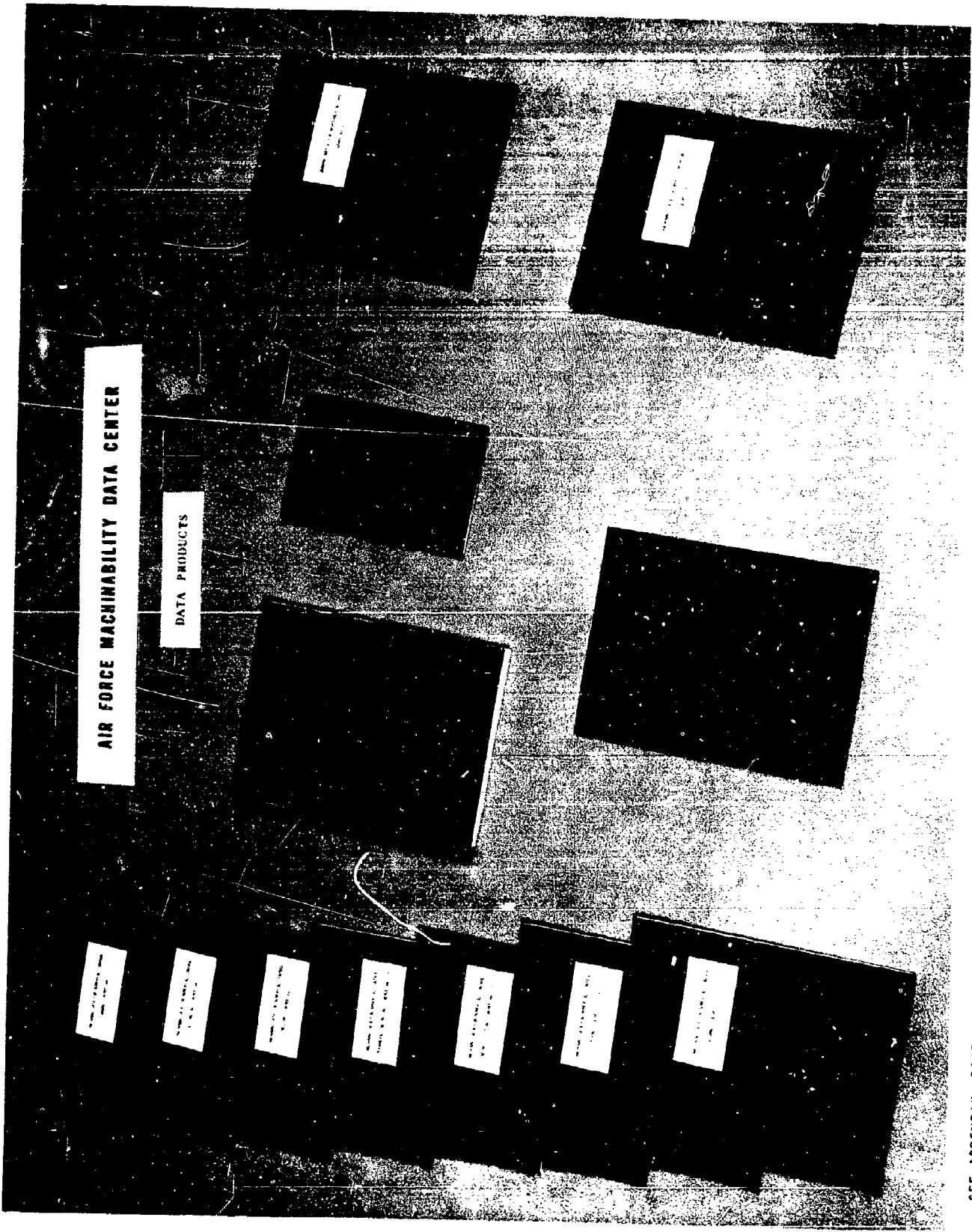
SUMMARY OF SPECIFIC INQUIRIES BY COMPANIES MAKING 5 OR MORE REQUESTS

October 1, 1964 - July 31, 1968

ABEX CORPORATION (3)*	16	GLIDDEN COMPANY (THE)	5
AEROJET-GENERAL CORPORATION (6)*	27	GOODYEAR AEROSPACE CORPORATION	17
AERONCA MANUFACTURING COMPANY	8	GRAY, G.A., COMPANY (THE)	8
AEROSPACE RESEARCH APPLICATIONS CENTER	18	GRUMMAN AIRCRAFT ENGINEERING CORP. (2)*	25
AIR FORCE, DEPARTMENT OF THE (7)*	9	HEWLETT PACKARD	6
ALLEGHENY-LUDLUM CO. (3)*	9	HOBART MANUFACTURING COMPANY (2)*	5
ALLIS-CHALMERS MANUFACTURING COMPANY (2)*	20	HOLLEY CARBURETOR COMPANY (2)*	13
ALTAMIL CORPORATION	7	HONEYWELL, INC. (4)*	17
AMERICAN SOCIETY OF TOOL & MANUFACTURING ENGINEERS (2)*	11	HUGHES AIRCRAFT COMPANY (6)*	26
AMERICAN SOCIETY FOR METALS	10	HUMBLE OIL & REFINING CO. (4)*	7
AMERICAN TOOL WORKS	7	IIT RESEARCH INSTITUTE	8
AMFORGE INC.	6	ILLINOIS, UNIVERSITY OF	8
ARGONNE NATIONAL LABORATORY	9	INGERSOLL MILLING MACHINE CO. (THE)	7
ARIZONA STATE UNIVERSITY	10	INGERSOLL RAND COMPANY (4)*	13
ARMCO STEEL CORPORATION (4)*	7	INTERNATIONAL BUSINESS MACHINE CORP. (10)*	20
ARMY, DEPARTMENT OF THE (2)*	6	INTERNATIONAL NICKEL Co., INC. (THE) (4)*	24
AVCO CORPORATION (8)*	27	JERDEN MANUFACTURING CO.	7
BARRY-WEHMILLER	8	JONES & LAMSON	10
BATTELLE MEMORIAL INSTITUTE (3)*	29	KENNAMETAL, INC. (4)*	15
BELL HELICOPTER COMPANY	7	KINSEY, E.A., COMPANY (THE)	7
BENDIX CORPORATION (THE) (13)*	91	KRONENBERG, DR. MAX	12
BERLIN SUPPLY COMPANY	5	LADISH COMPANY	9
BOEING COMPANY (THE) (6)*	67	LAKWOOD MANUFACTURING CO.	5
BOMAR COMPANY	6	LEBLOND, R.K. MACHINE TOOL CO. (THE) (2)*	15
BOOZ ALLEN, APPLIED RESEARCH, INC. (2)*	5	LING-TEMCO-VOUGHT, INC. (3)*	13
BORG-WARNER COMPANY (3)*	6	LITTON INDUSTRIES (2)*	7
BRUSH BERYLLIUM COMPANY (THE) (3)*	10	LOCKHEED AIRCRAFT CORPORATION (5)*	69
BUEHLER CORPORATION (THE)	7	LODGE & SHIPLEY COMPANY (THE)	6
BULLARD COMPANY (THE)	6	MACHINE DESIGN	5
BURNDY CORPORATION	6	MACHINERY (2)*	6
CALIFORNIA GENERAL, INC.	7	MARQUARDT CORPORATION (THE)	7
CARBORUNDUM COMPANY	14	MARQUETTE METAL PRODUCTS CO.	7
CARMET CORPORATION	5	MARTIN COMPANY (4)*	64
CARRIER AIR CONDITIONING CO.	6	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	5
CATERPILLAR TRACTOR COMPANY (2)*	5	MASSEY-FERGUSON INC.	6
CHRYSLER CORPORATION (3)*	6	MCDONNELL DOUGLAS CORPORATION (4)*	60
CINCINNATI, UNIVERSITY OF	10	MENASCO MANUFACTURING COMPANY (2)*	7
CINCINNATI LATHE & TOOL COMPANY	12	METALWORKING MAGAZINE	5
CINCINNATI MILLING MACHINE CO. (THE) (2)*	98	METCUT RESEARCH ASSOCIATES INC.	61
CINCINNATI SHAFER COMPANY	8	METEM CORPORATION	8
CLEVELAND AUTOMATIC MACHINE TOOL CO.	5	MICHIGAN, UNIVERSITY OF	8
CONTINENTAL AVIATION & ENGINEERING CORP. (2)*	11	MODERN MACHINE SHOP (3)*	7
CORNELL AERONAUTICAL LABORATORY, INC.	5	MONSANTO RESEARCH CORPORATION (3)*	9
CORNING GLASS WORKS	9	MOOG INC.	5
CRUCIBLE STEEL COMPANY OF AMERICA (3)*	12	MOREHEAD STATE UNIVERSITY	5
CUMMINS ENGINE COMPANY, INC.	6	NATIONAL AERONAUTICS & SPACE ADMINISTRATION (6)*	19
CURTISS-WRIGHT CORPORATION (3)*	100	NATIONAL LEAD COMPANY (2)*	20
DELAVAL TURBINE INC.	5	NAVY, DEPARTMENT OF THE (5)*	9
DO ALL COMPANY (2)*	6	NEW BRITAIN MACHINE CO. (THE) (2)*	8
DOW CHEMICAL COMPANY (3)*	14	NEW ENGLAND RESEARCH APPLICATION CENTER	16
DUNCAN MANUFACTURING CO.	6	NORTH AMERICAN ROCKWELL CORPORATION (9)*	104
DUPONT, E.I. DE NEMOURS & CO., INC. (3)*	38	NORTH CAROLINA STATE UNIVERSITY	9
DYNAMICS CORPORATION OF AMERICA	13	NORTHROP CORPORATION (2)*	8
ELECTRIC PRODUCTS INC. (2)*	13	NORTON COMPANY (2)*	10
ELECTRICAL MACHINING INC.	5	OWENS-ILLINOIS (3)*	11
ELECTRONICS SPECIALTY COMPANY	7	PENNSYLVANIA STATE UNIVERSITY (THE)	6
ELLIOT COMPANY	17	PHILCO CORPORATION (2)*	7
FEDERAL MOGUL CORPORATION	7		
FORD MOTOR COMPANY (5)*	18		
GARRETT CORPORATION (3)*	20		
GENERAL DYNAMICS CORPORATION (5)*	79		
GENERAL ELECTRIC COMPANY (35)*	311		
GENERAL MOTORS CORPORATION (15)*	57		

()* NO. OF DIVISIONS

PIONEER ASTRO INDUSTRIES INC.	5	THIOKOL CHEMICAL CORPORATION (2)*	12
PLANET PRODUCTS CORPORATION	9	TINKER AIR FORCE BASE	27
PRATT & WHITNEY AIRCRAFT (3)*	21	TOOL SALES & SERVICE	10
RADIO CORPORATION OF AMERICA (4)*	11	TOOL STEEL GEAR & PINION CO. (THE) (2)*	8
RAYTHEON COMPANY (4)*	7	U.S. DEPARTMENT OF COMMERCE (2)*	6
REACTIVE METALS, INC.	12	U.S. DEPARTMENT OF DEFENSE	5
REYNOLDS METALS COMPANY	7	U.S. NAVAL APPLIED SCIENCE LABORATORY (2)*	7
ROCK ISLAND ARSENAL	21	UTD CORPORATION (4)*	9
ROHR CORPORATION	12	UNION CARBIDE CORPORATION (7)*	70
SANDIA CORPORATION	17	UNITED AIRCRAFT CORPORATE SYSTEMS CENTER (3)*	16
SMALL BUSINESS ADMINISTRATION (12)*	48	VALERON CORPORATION (THE) (3)*	8
SOUTHERN ILLINOIS UNIVERSITY	11	VAN STRAATEN CHEMICAL COMPANY	5
SPERRY RAND CORPORATION (10)*	18	VERMONT AMERICAN CORPORATION	16
STANDARD OIL COMPANY (THE) (3)*	5	VERMONT, UNIVERSITY OF	11
STANDARD PRESSED STEEL CO.	6	WALMONT CORPORATION (THE) (2)*	5
STATE UNIVERSITY OF NEW YORK AT BINGHAMTON (2)*	5	WAUKESHA CUTTING TOOLS	5
STEEL MAGAZINE	12	WAYNE STATE UNIVERSITY	21
SUNDSTRAND CORPORATION (4)*	23	WESTERN ELECTRIC COMPANY, INC. (5)*	6
TRW, INC. (6)*	60	WESTINGHOUSE ELECTRIC CORPORATION (12)*	52
TELEDYNE COMPANY (6)*	18	WHITTAKER CORPORATION (3)*	6
TENNESSEE, UNIVERSITY OF (2)*	9	WINDSOR MANUFACTURING (2)*	10
TEXACO EXPERIMENT INC. (2)*	5	WRIGHT-PATTERSON AIR FORCE BASE (5)*	75
TERM, INC.	18	WYMAN-GORDON COMPANY (2)*	12
		XEROX CORPORATION	6



SEE APPENDIX, PAGE A-15

FIGURE 25

4 TOOL NOMENCLATURE

卷之三

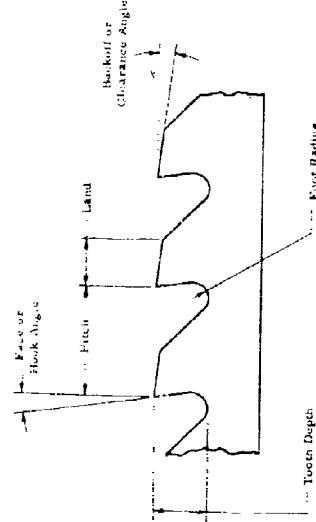


Fig. 1. -

BROACHING

International Team left to the International Day
of the Earth, September 22, 2009, Beijing.

SET 18874017 PAGE 1-15

TYPICAL FORMATS FOR DATA PRESENTATION

TURNING

MATERIAL	CONDITION	MICROSTRUCTURE	TOOL MATERIAL		TOOL GEOMETRY			CUTTING FLUID	DEPTH OF CUT in.	FEED ipr.	TOOL LIFE END POINT in.	TOOL LIFE - minutes vs SPEED-feet/minute R=Recommended Speed	
			BRINELL	TRADE NAME	INDUSTRY GRADE	SR°	SCER°	ECER°	RELIEF°	NOSE RADIUS in.			
HIGH TEMPERATURE ALLOYS - NICKEL BASE WROUGHT - (cont.)													
INCONEL 718	SOLUTION TREATED & AGED	AUSTENITIC	45 Rc	-	115 HSS	0	15	15	5	.032	.52	.060	.007 .40 3
INCONEL 718	SOLUTION TREATED & AGED	AUSTENITIC	45 Rc	R6	C-2	0	5	15	5	.032	11	.060C	.008 .123 .117 .90 29
INCONEL 718	SOLUTION TREATED & AGED	AUSTENITIC	45 Rc	R6	C-2	0	5	15	5	1:20	.060C	.015	.10 .15 .123 .117 .90

PERIPHERAL END MILLING

MATERIAL	CONDITION	MICROSTRUCTURE	TOOL MATT.		TOOL GEOMETRY			CUTTING FLUID	DEPTH OF CUT in.	FEED ipr.	TOOL LIFE END POINT in.	TOOL LIFE/CUTTER END POINT inches work travel vs SPEED-feet/minute R=Recommended Speed	
			BRINELL	TRADE NAME	INDUSTRY CUTTER TYPE	DIA. in.	TEETH	UP OR DOWN MILLING	FLUTE LENGTH in.	HELIX RR° ANGLE	CHAMFER EGEN° REL°	END PERIPH. REL°	
HIGH TEMPERATURE ALLOYS - NICKEL BASE WROUGHT - (cont.)													
INCONEL 718	SOLUTION TREATED & AGED	AUSTENITIC	42Rc	-	M2 HSS	.750	4	2 DOWN	30	10 .060°	1	3 11 1:20 .125 .750 .001 .012	.24 .11

DRILLING

MATERIAL	CONDITION	MICROSTRUCTURE	DRILL MATT.		DRILL SIZE			DRILL GEOMETRY	CUTTING FLUID	DEPTH OF HOLE in.	FEED ipr.	DRILL LIFE END POINT in.	DRILL LIFE NO. OF HOLES vs SPEED-feet/minute R=Recommended Speed
			BRINELL	TRADE NAME	INDUSTRY DRILL TYPE	DIA. in.	LENGTH in.	FLUTE LENGTH in.	TYPE POINT	HELIX POINT ANGLE	LIP RELIEF°		
HIGH TEMPERATURE ALLOYS - NICKEL BASE WROUGHT - (cont.)													
INCONEL 718	SOLUTION TREATED & AGED	AUSTENITIC	245	-	115 HSS	.250	2.5	1.375	CRANK-SHAFT	29	118 7	.5 .002 .015	.21 .25

DESCRIPTION & DISTRIBUTION OF AFMDC DATA PRODUCTS

AUGUST, 1965 - JULY 31, 1969

DESCRIPTION & CONTENT	NO OF COPIES DISSIMINATED
AFMDC 85-1. MACHINING DATA FOR TITANIUM ALLOYS, AUGUST 1965 TURNING, FACE MILLING, END MILL SLOTTING, PERIPHERAL END MILLING, DRILLING, REAMING, TAPPING, BROACHING, AND SURFACE GRINDING FOR COMMERCIALLY PURE TITANIUM, ALPHA & ALPHA-BETA, AND BETA ALLOYS.	5,926
AFMDC 66-1. MACHINING DATA FOR NUMERICAL CONTROL, DECEMBER 1966 CONTAINS ALL THE DATA ORIGINALLY PRINTED IN THE 7 INDIVIDUAL REPORTS, AFMDC 66-1.1 THROUGH 66-1.7. (See Notes.)	919
AFMDC 66-1.1. MACHINING DATA FOR NUMERICAL CONTROL - TURNING, JUNE 1966 FREE MACHINING PLAIN CARBON STEELS, PLAIN CARBON STEELS, FREE MACHINING ALLOY STEELS, ALLOY STEELS, ULTRA-HIGH STRENGTH STEELS, TOOL STEELS-HOT WORK, STAINLESS STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, REFRACOTY ALLOYS, AND NONMETALLICS.	1,171
AFMDC 66-1.2. MACHINING DATA FOR NUMERICAL CONTROL - FACE MILLING, AUGUST 1966 ALLOY STEELS, ULTRAHIGH STRENGTH STEELS, TOOL STEELS-HOT WORK, STAINLESS STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, REFRACOTY ALLOYS, AND NONMETALLICS.	1,107
AFMDC 66-1.3. MACHINING DATA FOR NUMERICAL CONTROL - DRILLING, AUGUST 1966 ALLOY STEELS, ULTRAHIGH STRENGTH STEELS, TOOL STEELS-HOT WORK, STAINLESS STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, REFRACOTY ALLOYS, AND NONMETALLICS.	1,093
AFMDC 66-1.4. MACHINING DATA FOR NUMERICAL CONTROL - PERIPHERAL END MILLING, SEPTEMBER 1966 ALLOY STEELS, ULTRAHIGH STRENGTH STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, AND REFRACOTY ALLOYS.	1,082
AFMDC 66-1.5. MACHINING DATA FOR NUMERICAL CONTROL - END MILL SLOTTING, SEPTEMBER 1966 ALLOY STEELS, ULTRAHIGH STRENGTH STEELS, TOOL STEELS-HOT WORK, STAINLESS STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, AND REFRACOTY ALLOYS.	1,065
AFMDC 66-1.6. MACHINING DATA FOR NUMERICAL CONTROL - TAPPING, NOVEMBER 1966 ALLOY STEELS, ULTRAHIGH STRENGTH STEELS, TOOL STEELS-HOT WORK, STAINLESS STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, REFRACOTY ALLOYS, AND NONMETALLICS.	1,060
AFMDC 66-1.7. MACHINING DATA FOR NUMERICAL CONTROL - REAMING, NOVEMBER 1966 ULTRA-HIGH STRENGTH STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, AND REFRACOTY ALLOYS.	1,060
AFMDC 66-2. GRINDING RATIOS FOR AEROSPACE ALLOYS, JUNE 1966 SURFACE GRINDING OF ALLOY STEELS, ULTRA-HIGH STRENGTH STEELS, TOOL STEELS, STAINLESS STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, REFRACOTY ALLOYS, AND NONMETALLICS.	927
AFMDC 66-3. MACHINING DATA FOR BERYLLIUM METAL, JUNE 1966 THIS BOOKLET COVERS PROBLEMS INVOLVED IN MACHINING BERYLLIUM, IN ADDITION TO SPECIFIC DATA FOR 10 CONVENTIONAL OPERATIONS AND 4 ALTERNATE MACHINING METHODS.	1,248
AFMDC 68-1. DETERMINATION AND ANALYSIS OF MACHINING COST AND PRODUCTION RATES USING COMPUTER TECHNIQUES, AUGUST 1968 THIS DATA PRODUCT DESCRIBES A PRACTICAL APPROACH TO THE PROBLEM OF OBTAINING MACHINING COSTS AND PRODUCTION RATES. IT INCLUDES EQUATIONS, NUMEROUS COMPUTER CALCULATIONS, AND COMPUTER SOURCE PROGRAM LISTINGS.	687
AFMDC 68-2, 1968 SUPPLEMENT TO MACHINING DATA FOR NUMERICAL CONTROL, AUGUST 1968 THIS SUPPLEMENT IS A COMPANION VOLUME TO MACHINING DATA FOR NUMERICAL CONTROL (AFMDC 66-1). MACHINING DATA ARE PRESENTED FOR THE NEWER AEROSPACE MATERIALS.	497
TOTAL	17,633

DATA ACQUISITION PLANT VISIT PROGRAM

LIST OF COMPANIES THROUGH JULY 31, 1969

Aerojet-General Corporation Sacramento, California	Lockheed Aircraft Corporation Sunnyvale, California
Aerospace Research Applications Center Bloomington, Indiana	Martin Company Orlando, Florida
AirResearch Manufacturing Company Phoenix, Arizona	Menasco Manufacturing Company Burbank, California
American Bosch Arma Corporation Garden City, New York	McDonnell Douglas Corporation Long Beach, California
American Welding & Manufacturing Company Warren, Ohio	McDonnell Douglas Corporation Santa Monica, California
Argonne National Laboratory Argonne, Illinois	McDonnell Douglas Corporation St. Louis, Missouri
Avco Corporation Nashville, Tennessee	North American Rockwell Corporation Anaheim, California
Beech Aircraft Corporation Wichita, Kansas	North American Rockwell Corporation Downey, California
Bell Helicopter Company Ft. Worth, Texas	North American Rockwell Corporation (2)* Canoga Park, California
Bendix Corporation Teterboro, New Jersey	North American Rockwell Corporation (4)* Los Angeles, California
Boeing Company (The) Wichita, Kansas	Northrop Norair Hawthorne, California
Boeing Company (The) (2)* Seattle, Washington	Northrop Ventura Newbury Park, California
General Dynamics Corporation San Diego, California	Pratt & Whitney Aircraft West Palm Beach, Florida
General Dynamics Corporation (3)* Ft. Worth, Texas	RCA Camden, New Jersey
General Electric Company Phoenix, Arizona	Sandia Corporation Albuquerque, New Mexico
Giddings & Lewis Inc. Fond Du Lac, Wisconsin	Solar/Div. of International Harvester San Diego, California
Grinding Wheel Institute Pittsburgh, Pennsylvania	Sperry Gyroscope Company Great Neck, New York
Hughes Aircraft Company Tucson, Arizona	Sperry Rand Corporation Sperry Flight Systems Division Phoenix, Arizona
Hughes Aircraft Company Culver City, California	TRW Cleveland, Ohio
Kaiser Aerospace & Electronics Glendale, California	Tinker Air Force Base Oklahoma City, Oklahoma
Kaiser Aerospace & Electronics (2)* San Leandro, California	Union Carbide Corporation Oak Ridge, Tennessee
Ling-Temco-Vought, Inc. Dallas, Texas	Western Electric Company, Inc. Oklahoma City, Oklahoma
Lockheed Aircraft Corporation (2)* Burbank, California	Westinghouse Electric Corporation Sunnyvale, California
Lockheed-Georgia Company Marietta, Georgia	

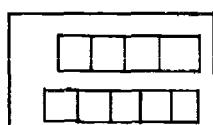
()* more than one visit

CODE SHEET FOR PROJECT TIME CARD

(USED BY EMPLOYEES FOR RECORDING HOURS ON DAILY TIME CARDS)

<u>DIRECT LABOR</u>		1000	
<u>INQUIRIES</u>			
<u>ENGINEERING SUPERVISION*</u>	1110	<u>DATA ACQUISITION - LITERATURE</u>	1270
INQUIRY STRATEGY AND INQUIRY APPRAISAL	1111	INDUSTRIAL CONTRIBUTORS OF MACHINING	
<u>MACHINING DATA ANALYSIS</u>	1120	REPORTS AND CASE HISTORIES	1271
ANSWERING INQUIRIES	1121	DOMESTIC PERIODICAL LITERATURE	1272
<u>DATA PROCESSING</u>	1130	FOREIGN PERIODICAL LITERATURE	1273
KEYPUNCHING	1131	INDUSTRIAL TRADE LITERATURE	1274
VERIFICATION	1132	TECHNICAL INSTITUTIONS, PROFESSIONAL	
SORTING	1133	SOCIETIES, AND ASSOCIATIONS	1275
CODING	1134	PUBLISHERS OF HANDBOOKS, MANUALS, BOOKS	1276
DECODING	1135	INFORMATION CENTERS	1277
COMPUTER PROCESSING	1136	GOVERNMENT AGENCIES	1278
<u>DATA CONTROL</u>	1140	MACHINABILITY LABORATORIES	1279
FORMS AND DOCUMENT HANDLING	1141	<u>DATA ACQUISITION - BY TECHNICAL PERSONNEL</u>	1280
<u>DATA ACQUISITION*</u>	1150	PLANT VISITS	1281
SPECIAL ACQUISITION FOR INQUIRIES	1151	TELEPHONE, TWX, TELEGRAM	1282
<u>REPRODUCTION*</u>	1160	LETTERS	1283
XEROX	1161	TECHNICAL MEETINGS (MACHINABILITY)	1284
DITTO	1163	TECHNICAL MEETINGS (INFORMATION SCIENCE)	1285
DRAWING	1165	FOREIGN PLANT VISITS	1286
<u>SYSTEMS ANALYSIS</u>	1170	FOREIGN TECHNICAL MEETINGS	1287
TECHNICAL REVIEW	1171	INDUSTRY SPECIAL	1288
COST EVALUATION	1172	<u>DATA STORAGE</u>	1290
<u>VISITS TO AFMDC - TECHNICAL*</u>	1180	DOCUMENT FILE	1291
MATERIALS SUPPORT DIVISION	1181	SUPPORT INFORMATION (BOOKS, ETC.)	1292
OTHERS	1182	<u>GENERAL DISSEMINATION OF MACHINABILITY</u>	
<u>ORIGINAL DATA ENTRY</u>			
<u>ENGINEERING SUPERVISION</u>	1210	<u>DATA AND CENTER INFORMATION</u>	
TECHNICAL PLANNING	1211	PUBLICATION IN TECHNICAL LITERATURE	1310
<u>MACHINING DATA ANALYSIS</u>	1220	PRESENTATION AT TECHNICAL MEETINGS	1311
PRELIMINARY SCREENING	1221	PRESENTATION AT PLANTS	1312
PRELIMINARY TECHNICAL EVALUATION	1222	STATE TECHNICAL SERVICER PROGRAMS	1313
FINAL TECHNICAL EVALUATION (put Document Control No. on Daily Time Slip)	1223	AFMDC EXHIBITS	1320
CORRELATION OF MACHINING DATA VARIABLES	1224	NEWSPAPERS (METALWORKING, ETC.) & MAGAZINES	1330
<u>DATA PROCESSING</u>	1230	USER LIST (TECHNICAL ASPECTS)	1340
KEYPUNCHING	1231	USER LIST PRODUCTS	1350
VERIFICATION	1232	NONTECHNICAL EDITING, REPRODUCTION &	
SORTING	1233	HANDLING	1355
CODING	1234	AFMDC PAMPHLETS, ANNOUNCEMENTS, ETC.	1360
DECODING	1235	SPECIAL REPORTS (STATE-OF-THE-ART, ETC.)	1370
COMPUTER PROCESSING	1236	BIBLIOGRAPHIES	1380
<u>DATA CONTROL</u>	1240	<u>AFMDC SYSTEM REPORTS AND MEETINGS</u>	
FORMS AND DOCUMENT HANDLING	1241	MONTHLY (MTD)	1410
<u>REPRODUCTION</u>	1250	QUARTERLY (MTD)	1420
XEROX	1251	ANNUAL (MTD)	1430
DRAWING OF DATA SHEETS, ETC.	1253	OPERATIONS MANUAL	1440
<u>SYSTEMS ANALYSIS</u>	1260	DETAILED CODE BOOK	1450
TECHNICAL REVIEW	1261	AFMDC MEETINGS	1460
COST EVALUATION	1262	AIR FORCE MATERIALS LABORATORY AND INFORMATION BRANCH MEETINGS, REPORTS, AND CONFERENCES	1470
DATA ACQUISITION EVALUATION	1263	SPECIAL REPORTS FOR MATERIALS SUPPORT DIVISION, DOD, ETC.	1480
<u>MACHINING DATA VERIFICATION - EXPERIMENTAL</u>			
(PROVISIONAL - PRESENTLY INACTIVE)			
PLANNING		1501	
TESTING		1502	
REPORTS		1503	

*Put Inquirer and Sequence numbers in Operation space
on Time Card. The Inquirer No. and Sequence No. are those
blocked out at the top of IF-1 as shown here:



CODE SHEET FOR PROJECT TIME CARD (continued)

SYSTEMS ANALYSIS - GENERAL

1130 COMPUTING SYSTEM (SYSTEMS ASPECTS)	1610
STATISTICAL PROGRAM FOR ANALYSIS OF CENTER EFFECTIVENESS (SPACE)	1620
1130 COMPUTING SYSTEM (TECHNICAL ASPECTS)	1630

PURCHASES

FOR PURCHASES PRECEDE CODE BY: 1000

Examples:

1000-1230 IBM CARDS FOR DATA PROCESSING, ETC.
1000-0000 INDIRECT CHARGES SUCH AS GENERAL SUPPLIES
1000-1272 PURCHASE OF DOMESTIC PERIODICAL LITERATURE

INDIRECT LABOR

GENERAL REPAIR, CLEANING, PAINTING	0101
TRAINING	0102
SICKNESS OR EXCUSED ABSENCE	0103
VACATION	0104
ACQUISITION OF MAJOR FACILITIES AND EQUIPMENT	0105
ACQUISITION OF MINOR EQUIPMENT AND SUPPLIES	0106
PROPOSALS AND SETTING UP PROGRAMS	0116
TECHNICAL MEETINGS AND PAPERS (NOT DIRECTLY RELATED TO AFMDC)	0127
GENERAL AFMDC CLERICAL AND OFFICE WORK	0128
GENERAL AFMDC ADMINISTRATION	0150
TYPING AND CLERICAL ON INQUIRIES	0151
TYPING AND CLERICAL ON ORIGINAL DATA ENTRIES	0152
HANDLING OF MAIL	0153
PERSONNEL (HIRING, ETC.)	0154
USER FILE (TYPING AND CLERICAL)	0155
VISITORS (TRANSPORTATION, SYSTEM DEMONSTRATION, GENERAL AFMDC INFORMATION)	0156
DATA PROCESSING (TIME CARDS, ETC.)	0157
TYPING AND CLERICAL ON USER PRODUCTS	0158
MISCELLANEOUS AFMDC NONCHARGEABLE SERVICES	0159
LIBRARY-SUPPORT INFORMATION	0160

AFMDC DAILY TIME SLIP

EMPLOYEE'S OPERATIONAL AREA (MACHINING DATA ANALYSIS)			
EMPLOYEE NUMBER			
METCUT RESEARCH ASSOCIATES INC			
ANSWERING INQUIRIES	DAILY TIME SLIP		
OPERATIONAL AREA (MACHINING DATA ANALYSIS- CODE 4)	NAME R. E. SNIDER		
FINAL TECHNICAL EVALUATION	CLOCK NO. 4-220 DATE 9-18-68		
WORK IN ANOTHER OPERATIONAL AREA (DATA ACQUISITION- CODE 7)	JOB NO.	OPERATION	✓ TIME ELAPSED
	4-1721	0009-11067	2.0
	4-1350	950003-68	1.0
	4-1223		3.5
	7-1281		1.0
			8.0
	APPROVED	TIMEKEEPER	
	<i>jm</i>		

COMPUTER PRINTOUT OF AFNOC PROJECT TIME CARDS

PROJECT CLASS	LABOR TYPE	EMPLOYEE INFORMATION	ELAPSED HOURS	DATE	PROJECT NUMBER-INDEX	LIST PAYROLL
5 1231	1	5 459 V HEITKEMPE	1.50	9 16 68	950999	68
5 1241	1	5 459 V HEITKEMPE	1.00	9 16 68	950999	68
		5 459	2.50	***		
5 1136	1	5 384 C CROCKETT	4.00	9 17 68	950999	68
5 1232	1	5 384 C CROCKETT	1.00	9 18 68	950999	68
5 1430	1	5 384 C CROCKETT	2.50	9 19 68	950999	68
		5 384	7.50	***		
4 1350	1	4 240 A F ACKENHAUS	0.50	9 19 68	950003	68
4 1350	1	4 240 A F ACKENHAUS	1.50	9 19 68	950003	68
		4 240	4.50	***		
4 1350	1	4 240 A F ACKENHAUS	2.50	9 20 68	950006	68
50		4 240	13.50	***		
4 1223	1	4 235 C MEHL	2.00	9 15 68	950999	68
4 1223	1	4 235 C MEHL	5.00	9 14 68	950999	68
4 1223	1	4 235 C MEHL	6.50	9 18 68	950999	68
		4 235	13.50	***		
4 1121	1	4 220 R SNIDER	1.00	9 23 68	0846 11029	
4 1121	1	4 220 R SNIDER	1.00	9 24 68	0154 11055	
4 1121	1	4 220 R SNIDER	1.00	9 25 68	0024 11063	
4 1121	1	4 220 R SNIDER	1.00	9 26 68	0028 11058	
		4 220	4.00	***		
2 1111	-	2 101 J MARANCHIK	2.00	9 23 68	950999	68
2 1430	-	2 101 J MARANCHIK	2.00	9 24 68	950999	68
		2 101	4.00	***		
				DECK TOTAL HOURS =	36.00	

SEE APPENDIX, PAGE A-16

FIGURE 31

AFMDC OPERATING COSTS

OCTOBER 1, 1968 - JULY 31, 1969

INPUT COSTS	
TECHNICAL EVALUATION	\$ 37,628.04
DATA PROCESSING	26,703.77
DOCUMENT ACQUISITION & REPRODUCTION	<u>18,588.70</u>
	80,920.51
EQUIPMENT, SUPPLIES & SERVICES	<u>10,641.73</u>
	TOTAL 91,562.24
OUTPUT COSTS	
<u>INQUIRIES:</u>	
TECHNICAL EVALUATION	\$ 45,283.70
DATA PROCESSING & RETRIEVAL	11,588.60
DATA ACQUISITION & REPRODUCTION	<u>6,109.20</u>
GOVERNMENT AGENCIES	4,849.58
(NOT INCLUDING SBA & STSP)	
ALL OTHER ORGANIZATIONS	<u>58,131.92</u>
	TOTAL 62,981.50
<u>DATA PRODUCTS:</u>	
DATA PRODUCTS COMPLETED & IN PROCESS (INCLUDING PRINTING COSTS)	\$ 19,295.62
EQUIPMENT, SUPPLIES & SERVICES	<u>8,456.47</u>
	TOTAL 25,752.06
	88,733.59
GENERAL DISSEMINATION	
GENERAL DISSEMINATION OF MACHINABILITY DATA & CENTER INFORMATION	\$ 4,289.76
EQUIPMENT, SUPPLIES & SERVICES	<u>1,403.88</u>
	TOTAL 5,693.64
REPORTS	
<u>AFMDC SYSTEMS REPORTS:</u>	
AFMDC, MSD AND INFORMATION BRANCH MEETINGS AND SPECIAL MSD REPORTS	\$ 16,574.08
EQUIPMENT, SUPPLIES & SERVICES	<u>4,482.48</u>
	TOTAL 21,056.57
SYSTEMS ANALYSIS, MODIFICATION & CONTROL	
TECHNICAL EVALUATION	\$ 2,818.88
DATA PROCESSING - IBM 1130 COMPUTING SYSTEM:	
TECHNICAL ASPECTS	1,139.81
SYSTEMS ASPECTS	9,820.27
OPERATIONS MANUAL & CODE BOOK REVISIONS & ADDITIONS	<u>1,525.00</u>
EQUIPMENT, SUPPLIES & SERVICES	15,404.14
	<u>1,529.78</u>
	TOTAL 16,933.90
TOTAL ACTUAL COSTS NOT INCLUDING FIXED FEE	\$ 223,859.94

AFMDC INPUT & OUTPUT SUMMARY

October 1, 1964 - July 31, 1969

SYSTEM INPUT

Document and Card Totals

Documents Entered into the System (including Specific Inquiries)

Oct. 1, 1964 - Jan. 31, 1967	17,576
Feb. 1, 1967 - Jan. 31, 1968	3,695
Feb. 1, 1968 - Sept. 30, 1968	2,341
Oct. 1, 1968 - July 31, 1969	3,316
Total	26,928

Evaluated Documents (including Specific Inquiries)

Oct. 1, 1964 - Jan. 31, 1967	9,367
Feb. 1, 1967 - Jan. 31, 1968	3,734
Feb. 1, 1968 - Sept. 30, 1968	2,840
Oct. 1, 1968 - July 31, 1969	3,780
Total	19,721

Total Cards Punched

Oct. 1, 1964 - Jan. 31, 1967	75,173
Feb. 1, 1967 - Jan. 31, 1968	27,077
Feb. 1, 1968 - Sept. 30, 1968	13,833
Oct. 1, 1968 - July 31, 1969	33,868
Total	149,951

SYSTEM OUTPUT

Specific Inquiries

Inquiries Received October 1, 1964 - January 31, 1966	595
Individual Organizations Represented	314
U.S. Government Standard Industrial Classification (SIC) Represented	72
Inquiries Received February 1, 1966 - January 31, 1967	736
Individual Organizations Represented	396
U.S. Government Standard Industrial Classification (SIC) Represented	90
Inquiries Received February 1, 1967 - January 31, 1968	1,002
Individual Organizations Represented	485
Individuals Represented	690
U.S. Government Standard Industrial Classification (SIC) Represented	96
Inquiries Received February 1, 1968 - September 30, 1968	982
Individual Organizations Represented	439
Individuals Represented	596
U.S. Government Standard Industrial Classification (SIC) Represented	105
Inquiries Received October 1, 1968 - July 31, 1969	1,141
Individual Organizations Represented	520
Individuals Represented	753
U.S. Government Standard Industrial Classification (SIC) Represented	106

AFMDC INPUT & OUTPUT SUMMARY (con't.)

<u>Data Products</u>	<u>Copies Distributed</u>
AFMDC 65-1, Machining Data for Titanium Alloys	5,925
AFMDC 66-1, Machining Data for Numerical Control	910
AFMDC 66-1.1, Machining Data for Numerical Control-Turning	1,171
AFMDC 66-1.2, Machining Data for Numerical Control-Face Milling	1,107
AFMDC 66-1.3, Machining Data for Numerical Control-Drilling	1,093
AFMDC 66-1.4, Machining Data for Numerical Control-Peripheral End Milling	1,082
AFMDC 66-1.5, Machining Data for Numerical Control-End Mill Slotting	1,065
AFMDC 66-1.6, Machining Data for Numerical Control-Tapping	1,060
AFMDC 66-1.7, Machining Data for Numerical Control-Reaming	1,060
AFMDC 66-2, Grinding Ratios for Aerospace Alloys	927
AFMDC 66-3, Machining Data for Beryllium Metal	1,248
AFMDC 68-1, Determination & Analysis of Machining Cost & Production Rates Using Computer Techniques	687
AFMDC 68-2, 1968 Supplement to Machining Data for Numerical Control	497
<u>Unit Costs</u>	
Per Inquiry (595) - Oct. 1964 - Jan. 1966	\$ 47.49
Per Inquiry (736) - Feb. 1966 - Jan. 1967	45.02
Per Inquiry (1002) - Feb. 1967 - Jan. 1968	52.66
Per Inquiry (982) - Feb. 1968 - Sept. 1968	58.58
Per Inquiry (1141) - Oct. 1968 - July 1969	55.19
Average Cost Per Inquiry (4456) - Oct. 1964 - July 1968	51.79

ECONOMIC ENVIRONMENT FOR AFMDC OPERATIONS (ANNUAL COSTS)

Labor and Overhead Costs for Operating Metal Cutting Machine Tools in the Metalworking Industries in the United States

Based on the 1963 Inventory and actual 1964 and 1965 metal cutting machine tool shipments, American Machinist estimated that approximately 2,500,000 machine tools were in use at the end of 1965.

Total number of metal cutting machine tools in the metalworking industries	=	2,500,000
Average labor cost + overhead	=	\$8.00 per hour
Average working day	=	8 hours
Number of working days per year	=	250
Average number of direct labor personnel per machine	=	1
Total cost of Labor + Overhead: 2,500,000 x \$8.00 x 8 x 250 x 1	=	\$40,000,000,000

\$40,000,000,000

Total Shipments Including Exports of Metal Cutting Type Metalworking Machinery

\$1,040,766,000 (1965)

Source: U.S. Department of Commerce

Machine Tool Accessories Industry

\$971,000,000

(including small cutting tools for machine tools and metalworking machinery in the amount of \$598,000,000)

Source: 1965 Census of Manufacturers
Bureau of Census

Cutting Fluids

\$35,000,000

Source: "Coolant Control... a plant study plan" by B. F. Wilson,
Automatic Machining, June 1965.

POTENTIAL FOR AFMDC SERVICES TO INDUSTRY

PARTIAL LIST FROM DUN & BRADSTREET METALWORKING, DIRECTORY 1967-68				AFMDC SUMMARY OF INQUIRIES FOR 8 SIC GROUPS OCTOBER 1, 1964 - JULY 31, 1969	
STANDARD INDUSTRIAL CLASSIFICATION (SIC) NUMBER & INDUSTRY CLASSIFICATION	MAJOR PRODUCT MANUFACTURED NO. OF COMPANIES*	NO. OF INDIVIDUALS	MINOR PRODUCT MANUFACTURED NO. OF COMPANIES	INQUIRIES	NO. OF AFMDC COMPANIES
MAJOR GROUP 37 - TRANSPORTATION EQUIPMENT NO.					
3721 - AIRCRAFT & MISSILES	74	22,197	7	823	54
3722 - AIRCRAFT ENGINES & PARTS	119	185,333	69	374	32
3723 - AIRCRAFT PROPELLERS & PROPELLER PARTS	13	11,284	12	—	—
3729 - AIRCRAFT PARTS & AUXILIARY EQUIPMENT	589	189,521	380	164	75
MAJOR GROUP 33 - PRIMARY METAL INDUSTRIES	3,669	1,360,594	2,442	261	87
MAJOR GROUP 34 - FABRICATED METAL PRODUCTS, EXCEPT ORDINANCE, MACHINERY & TRANSPORTATION EQUIPMENT	10,241	1,296,147	6,842	202	78
MAJOR GROUP 35 - MACHINERY, EXCEPT ELECTRICAL	9,933	1,941,820	7,345	971	418
MAJOR GROUP 36 - ELECTRICAL MACHINERY, EQUIPMENT & SUPPLIES	4,793	1,893,661	2,966	317	103
	29,431	6,900,557	20,063	3,112	847

* 20 or more employees

SEE APPENDIX, PAGE A-18

FIGURE 35

COST SAVINGS RESULTING FROM AFMDC'S OPERATION

OCTOBER 1, 1964 - JULY 31, 1968

COST SAVINGS RESULTING FROM AFMDC'S RESPONSE TO SPECIFIC INQUIRIES

Total Number of Specific Inquiries 4,456

Estimated Total Number of Machining Situations Included in the 4,456
Inquiries - 22,930

Estimated Savings per Machining Situation Response - \$800.00

Estimated Total Savings Resulting from Specific Inquiries - 22,930
Machining Situations x \$800.00 - \$18,344,000.00

COST SAVINGS RESULTING FROM AFMDC'S 13 DATA PRODUCTS

Total Number of Data Product Copies Distributed - 17,833

Estimated Number of Machining Situations Utilized per Data
Product Copy - 5

Estimated Total Number of Machining Situations - 17,833 Data Product
Copies x 5 - 89,165

Estimated Savings per Machining Situation - \$300.00

Estimated Total Savings Resulting from Data Products - 89,165 Machining
Situations x \$300.00 - 26,749,500.00

Total Estimated Cost Savings Resulting from AFMDC'S Operation

\$ 45,093,500.00

AFMDC PLANS FOR RECOVERY OF OUTPUT COSTS

PROPOSED INQUIRY CHARGES BASED ON ANALYSES OF INQUIRIES FOR THREE YEAR PERIOD

JANUARY 1, 1966 - DECEMBER 31, 1968

ORGANIZATION	NO. OF INQUIRIES	NO. OF MACHINING SITUATIONS	(A) ESTIMATED COST SAVINGS	AVERAGE SAVINGS/YEAR	ESTIMATED NO. INQUIRIES/YEAR	(B) AVERAGE COST/YEAR
(L) COMPANY A	13	100	\$ 80,000.00	\$ 26,666.00	5	\$ 500.00
(L) COMPANY B	6	42	33,800.00	11,200.00	2	200.00
(L) COMPANY C	7	55	44,000.00	14,666.00	3	250.00
(L) COMPANY D	10	75	60,000.00	20,000.00	4	400.00
(L) COMPANY E	24	192	153,600.00	51,200.00	8	1,000.00
(L) COMPANY F	6	45	36,000.00	12,000.00	2	250.00
(L) COMPANY G	71	632	905,600.00	188,533.00	25	3,250.00
(L) COMPANY H	77	625	500,000.00	166,666.00	25	3,000.00
(L) COMPANY I	27	250	200,000.00	66,666.00	10	1,250.00
(L) COMPANY J	9	75	80,000.00	20,000.00	3	400.00
(L) COMPANY K	37	275	220,000.00	73,333.00	15	1,500.00
(L) COMPANY L	13	160	128,000.00	42,666.00	5	850.00
(L) COMPANY M	13	107	74,900.00	24,966.00	5	500.00
(L) COMPANY N	109	800	640,000.00	213,333.00	35	4,000.00
(L) COMPANY O	6	43	34,400.00	11,465.00	2	209.00
(L) COMPANY P	27	250	200,000.00	66,666.00	9	1,250.00
(L) COMPANY Q	13	100	80,000.00	26,666.00	5	500.00
(L) COMPANY R	27	195	156,000.00	52,000.00	10	1,000.00
(L) COMPANY S	28	225	180,000.00	60,000.00	10	1,000.00
(S) COMPANY T	7	55	44,000.00	14,666.00	3	250.00
(L) GOVERNMENT AGENCY A	2	20	16,000.00	5,333.00	1	100.00
(L) COMPANY U	12	102	81,600.00	27,200.00	5	500.00
(L) COMPANY V	25	200	160,000.00	53,333.00	8	1,000.00
(L) COMPANY W	11	85	68,000.00	22,666.00	4	500.00
(L) GOVERNMENT AGENCY B	14	112	89,600.00	26,666.00	5	500.00
(S) GOVERNMENT AGENCY C	3	25	20,000.00	6,666.00	300.00	300.00
(L) COMPANY X	16	135	108,000.00	36,000.00	5	100.00
(L) GOVERNMENT AGENCY D	6	40	32,000.00	10,666.00	2	200.00
(S) UNIVERSITY A	3	25	20,000.00	6,666.00	1	100.00
(L) UNIVERSITY B	3	25	20,000.00	6,666.00	10(C)	300.00
(S) COMPANY Y	11	125	100,000.00	33,333.00	4	650.00
(L) COMPANY Z	11	100	80,000.00	26,666.00	4	500.00
(L) GOVERNMENT AGENCY E	27	200	160,000.00	53,333.00	10	1,000.00

(A) Based on Estimated Cost Savings of \$800.00 per Machining Situation

(B) Based on the Organization Savings of \$50.00 for each \$1.00 invested

(C) Estimated Number of Inquiries based on recent increased activity

(L) Large Company

(I) Intermediate Company

(S) Small Company

SEE APPENDIX, PAGE A-20

FUTURE PLANNING

MAJOR GOALS

1. Prepare and publish a major revision of the Machining Data Handbook. This will require a significant amount of AFMDC effort.
2. Prepare cost savings analyses, proposed inquiry charges and related information for the potential subscribers to AFMDC's services.
3. Begin to institute inquiry charges to AFMDC's users.
4. Plan and institute a program designed to produce a high volume of sales of the Machining Data Handbook in order to recover costs incurred in its preparation and publication.
5. Set up seminars at AFMDC and in selected areas whereby key personnel involved in manufacture of advanced aerospace vehicles will be invited to attend. One of the prime subjects to be discussed at these seminars will be the machining of titanium alloys which will be in heavy usage in these vehicles.
6. Continue the analyses of the considerable hard machining data in AFMDC storage with the assist of the computer. The main objective is to determine what relationships and correlations may exist between the various types of machining parameters and work materials.
7. Increase utilization of AFMDC to meet the needs of industry personnel who have the responsibility for producing hardware and solving machining problems.
8. Continue to identify and make personal contacts with personnel in all echelons who can utilize machining information available from the Center. Emphasis will be given to contractors, subcontractors and sub-subcontractors producing components for advanced aerospace vehicles.
9. Continue coordination with the various State Technical Services Programs and Small Business Administration Technology Utilization Programs. Also, close cooperation will continue with the National Referral Center and other Centers.
10. Establish closer coordination with the Foreign Technology Division for the purpose of more extensive utilization of the foreign literature in their files and wider dissemination of this information.
11. Continue the program of plant visitation to make industry aware of the data stored by AFMDC and to obtain cooperation for input to AFMDC.
12. Continue to study the potential of a computer data-link by users of the Center.

APPENDIX

Description of AFMDC (page 1)

This description of AFMDC is distributed by the Center in the form of a pink flyer (3-1/2" x 7-1/2") with the information relating to Scope, Collection, and Information Services on one side of the card and with instructions on how to request machining information from AFMDC on the other side. The pink flyer is convenient in size which makes it possible to include it in all types of mailings and to use it for handouts at meetings and for Center visitors. Various plants have also used AFMDC flyers to acquaint machining personnel with Center services.

By including detailed information on how to request machining information, it is hoped that some loss in time can be avoided and that the search strategy required will be simplified. Information shown on page 1 has also been furnished for the Air Force Materials Information Centers (AFMIC) booklet, February 1968.

AFMDC Organization Chart (Figure 1, page 2)

This Organization Chart is self-explanatory, but certain comments may be helpful toward gaining a fuller understanding of the basic plan. One of the most important aspects of AFMDC's organization relates to use of engineering personnel. These persons are professionally trained, experienced people who have the capability of judging the value of machining information for input purposes and to make technical analyses of output used for answering specific inquiries as well as developing data products.

Systems Analysts are employed on a part-time basis, with emphasis being placed in three areas: 1) Data Processing, 2) Document Processing, and 3) Data Acquisition. Consultants are used to a limited extent.

Up to the present time, almost complete emphasis on document acquisition has been given to domestic considerations. Since the foreign literature and foreign efforts relating to machinability are significant, this area has been covered by using a consultant to report on foreign trends as they may influence need for domestic cognizance.

Since AFMDC is operated by Metcut Research Associates Inc., full advantage is taken of the capabilities of Metcut personnel not associated with AFMDC on a full-time basis. This includes Dr. Michael Field, president of Metcut, Mr. Norman Zlatin, vice-president of Metcut, Dr. John F. Kahles, vice-president of Metcut, and Mr. John Christopher, who is a project engineer in charge of experimental machining data being developed at Metcut.

Since metal removal is a very complex technical discipline, it is obvious that not all of the capability required can be centered in one organization, and therefore use has been made of part-time analysts, located at several companies.

Two important areas of AFMDC systems are document acquisition and data processing. Document acquisition is responsible for acquiring input from both domestic and foreign sources covering the entire broad scope of machining information required to meet the output of the Center. Data processing is a key function required for storage and retrieval of the detailed evaluated and coded information extracted by Machining Data Analysts. Mechanical processing of data was accomplished prior to July 1, 1966, by Electrical Accounting Machine (EAM) equipment. Part of this equipment now supports the IBM 1130 computer, which is the medium for storage and retrieval of processed information.

From an information point of view, the Organization Chart also reflects handling aspects of information which do not require full-time activity. Trained competent secretarial personnel handle activities of the files pertaining to inquiries and data products.

Part-time Systems Analysts are used to develop required computer programs and systems evaluation of current operations. Capability of full-time engineering and data processing personnel has been developed to supplement the effort now being expended by part-time Systems Analysts.

AFMDC Operational Areas (page 3)

Each of the functional areas of operation of AFMDC has been assigned a code number from 1 through 9 and 0. These time codes are used in connection with the codes shown in Figure 29, pages 47 and 48, Code Sheet for Project Time Card. For example, a Machining Data Analyst in functional area No. 4 who is answering inquiries will use the code 4-1121. If a Machining Data Analyst in area No. 4 is performing in another operational area, such as assisting in technical aspects of document acquisition by obtaining data from industrial plants (see Figure 29, pages 47 and 48, time code 1281), he will use the time code 7-1281. Since the project time card also includes his employee number and the operational area in which he functions, it is possible to determine the extent of time spent by employees in their principal assigned area as compared with time they spend in other functional areas of the Center (see actual Daily Time Slip, Figure 30, page 49). More important, the stored punched card information from the project time card is valuable in providing detailed analyses of the various cost aspects pertaining to the Center's operation.

AFMDC Operations Chart (Figure 2, page 4)

Basically the Operations Chart divides functions into two principal parts: 1) System Input and 2) System Output. The other function shown in the heading is System Analysis and is linked to input and output to

insure and measure the effectiveness of the two major functions. All sources of information are referenced as documents' regardless of whether they are journals, books, technical reports, data sheets, micro-film, abstracts, etc.

System Input consists of the steps shown in Figure 2, page 4, which are designed to accept any type of document from any source and process it so that each document becomes an entity within the system. The steps are set so that documents may be evaluated as to the nature of the information contained in view of the computer programs and codes which were established and are modified by System Analysis. In the preliminary screening step judgments are made by engineering personnel as to whether documents received at AFMDC have valuable machining information. The selected documents are then sent on to engineering personnel for technical evaluation and the important information is extracted and recorded using established codes and formats.

The depth to which a particular document is evaluated and the amount of information extracted is dependent mainly on three factors: 1) the amount of hard machining data, 2) the anticipated utilization of the information, based on previous inquiry experience, 3) the amount of good reliable information already in the files. In cases when a document contains a limited amount of good information, only seven parameters of a machining situation are identified, if available: 1) machining operation, 2) material hardness, 3) material condition, 4) heat treatment, 5) material group, 6) material description, 7) tool material. All of the significant reported information for each machining situation is extracted from high yield documents, including numerical data and tool geometry. The extracted information is placed on the forms in Figure 4, page 7. These forms are given to a key punch operator who punches cards which will be stored on the computer. A printout of this type of information is shown in Figure 8, page 11. All documents are assigned uniterms, where applicable, to describe the text to the system. These uniterms, together with the source control number, are punched into cards. An example of a computer printout of a search made on the Uniterm File is shown in Figure 7, page 10.

System output consists of the three basic types of output: 1) specific inquiries, 2) data products and 3) general dissemination. Specific inquiries may be submitted to AFMDC by anyone qualified as a User of AFMDC. The request may be for specific data for a machining situation or series of machining operations, state-of-the-art studies, etc. A list of the types of inquiries is shown in Figure 15, pages 18 and 19.

Data products are published by AFMDC on timely subjects which are comprehensive studies and generally take the form of charts of data for one or more alloys. The charts contain all the known data for machining parameters, tool geometry, cutting fluid, tool material and other considerations directly applicable to the machining situation. When data products become available a notice is sent to every individual on the User File. Through this notice the User is made aware of information that may be applicable to his needs.

General dissemination takes the form of plant visits for coordination (see page 46), writing technical papers or preparing exhibits for presentation at meetings or presentation in the literature. AFMDC is always open to visitors and technical personnel are available to discuss various problems in detail and to show the User how AFMDC can assist his operation.

AFMDC User File Map (Figure 3, page 5)

The User File map shows the number of organizations per state and the total number of individual Users in those organizations per state. These figures include Industrial Firms, Government Agencies, Universities, Colleges, other Centers, Publishers and Societies. Four states have no Users and 17 states have 10 or less organizations. As would be expected, the heavy concentration of Users is in heavy industrial sections and the West Coast aerospace industry.

Distribution of AFMDC User File (page 6)

The basic User File was developed by using the following sources:

World Space Directory, Volume 3 No. 1 - This directory contains a large index of plants associated with the aerospace industry. An important section lists the "Major Missile and Space Manufacturers". Request forms were sent to key people in all of the company listings in this section, and provision was made in the form allowing for listing additional personnel, personnel from other divisions and major subcontractors.

Manufacturing Committee of the Aerospace Industries Association, Washington, D.C. - This is an important aerospace group which has need for machining information in the solution of their common industry problems.

The American Society for Engineering Education (including members of the Engineering College Administrative Council, Engineering College Research Council, Technical Institute Council and Industrial Members) - Letters were sent to the deans of all of the important colleges which have significant interest in machining through departments such as: Aeronautical Engineering; Ceramic Engineering; General Engineering; Industrial Engineering; Mechanical Engineering; Metallurgical Engineering; Pre-Engineering; Engineering Extension Groups; Control, Computer and Information Science Departments; Material and Engineering Sciences; and Technical Engineering Institutes and Engineering Research Groups oriented in disciplines of materials and material removal. Products of the Center have been helpful to college students, some of whom are already engaged in time standards work, manufacturing engineering, etc., in cooperative work programs and in summer jobs. Even more important is the fact that the training of engineers and thus their future professional performance will be influenced through AFMDC's activities.

Information Sources - Listings were compiled from "A Directory of Information Resources in the United States", National Referral Center for Science and Technology, Library of Congress, January 1965. The prime function of the Referral Center is to direct people to the proper information sources, including Centers, in the United States. Their directory contains a large listing of Centers, Technical Societies, Government agencies, etc., which in turn disseminate information to their various clientele. This directory was reviewed and selections for the User File were made.

1964 "ASM Index for the Review of Metal Literature" - This list includes societies and trade publications in the United States, and from it selections were made of those concerned with material removal.

Manufacturing Technology Division, Wright-Patterson AFB, Ohio, Report Distribution Lists - It should be noted that these distribution lists include other Departments of the Air Force, the Departments of the Army, Navy, Defense and other Government agencies.

Inquirers - People who request information from AFMDC are termed 'inquirers'. New inquirers not already listed in the User File are added to it. Since there have been 4,456 inquiries during the 4-3/4 years operation of AFMDC, it is quite obvious that the file will grow considerably from this source alone.

Materials Advisory Board (MAB) Committee on Manufacturing Requirements for Aerospace Materials and the Ad Hoc Committee on Aerospace Manufacturing Requirements - This group was contacted because of its importance in manufacturing planning at a national level.

Dun & Bradstreet Metalworking Directory - This directory provides a comprehensive list of firms in the metalworking field. A substantial number of firms listed in the directory were provided information describing the Center's services.

In order to keep the User File current, each individual on the User File is periodically contacted to ascertain whether he wishes to continue to be listed and whether there are any changes in position and address. Names are added to the User File as a result of: 1) inquirers, 2) visitors, 3) additional names submitted by current users, 4) requests resulting from dissemination of data products and 5) technical articles published in periodicals and announcements pertaining to the Center.

Page 6 indicates that there are listed in the User File a total of 5,315 individuals from a total of 2,063 organizations.

Data Code Forms for Final Technical Evaluation (Figure 4, page 7)

Figure 4, page 7, is a photograph showing both the front and back of Data Code Forms used as an intermediate step between the original document and the punched cards used as input to disk storage. The formats are designed to handle alphabetic information required for some parameters and decimal numbers for others, as well as integers. These formats and a book with codes enable the Machining Data Analyst to concisely identify the important information regarding a specific machining situation. Required decimals are set in the numerical data fields, thereby further simplifying recording of the data. These forms are then passed to the keypunch operator, who punches the information contained in them into Index, Tool-Cutting Fluid and Numerical Data Cards.

These, plus the additional cards used by AFMDC are described as follows:

<u>Card</u>	<u>Description</u>
0 Inquiry	The Inquiry Card is punched with the inquiry information desired and is used by matching key indices in exactly the same columns as information which would have been pre-coded into the System.
1 Index	The Index Card establishes information available in the System by preassigned data index columns and respective codes to be matched against inquiries. This card describes the machining situation including the machining operation, specific material designation, hardness, condition, heat treatment, and broad material group. In addition to the above "minimum requirements", the Index Card also includes the part configuration code, tool material, machine tool description and the control codes. The control codes provide information on the data source, its classification and index controls which allow for retrieval monitoring. The primary method of access into the AFMDC information decks is through the Index Card.
2 Tool - Cutting Fluid	This card defines tool size, shape, and geometry, as well as the trade name and manufacturer. It also identifies the trade name of the cutting fluid, the manufacturer and the concentration of the cutting fluid.
3 Numerical Data	The Numerical Data Card contains actual values of machining variables, such as feeds, speeds, depth of cut, hole size, tool life, etc.
4 Unitem (key word)	This card alphabetically describes special technical significance of a document not covered by categories included on the Index, Numerical Data and Tool-Cutting Fluid Cards.

5 Data Link This card provides means for eliminating the recording of data relevant to different topics or sources. Data are coded and stored under one control code.

6 Aperture The Aperture Card is used to store and retrieve microfilms of pertinent curves, drawings or any information best stored in a graphic manner.

7 Bibliography The Bibliography Card set is designed to present the Source Document in a formalized, uncoded manner.

8 Potential Source of Information This card records into the System information on contracts awarded and other work initiated or in progress which are considered potential information sources. In this manner, the card helps direct an active data acquisition program. It also serves as a card to store certain bibliographic information such as author and organization.

8 Visitor This card has the same format as the Potential Source of Information Card and therefore serves not only to develop a Visitor File but can and is used to identify visitors as inquirers and/or potential sources of information.

9 Tickler The Tickler Card is generated at the time machining information is committed to the System primarily as a review device for updating, purging, etc., but also for checking on commitments for potential sources of information. Dates for tickler review of data committed to the System are based upon the times related and shown in the Classification Code.

Flowchart for Fortran Program to Store, Add to, or Search Inquiry File (Figure 5, page 8)

The flowchart of the Inquiry File program, shown in Figure 5, page 8, is an example of the data storage and retrieval techniques used by AFMDC on its IBM 1130 Computing System. Similar programs are used to maintain and search files of coded information concerning the documents in AFMDC's files. The search strategy incorporated in the Document File programs is approximately the same as that used by the Inquiry File program. However, separate programs and files are used for index information and unitem information on the document files.

All of these programs perform two fundamental functions: (1) generate and maintain their respective disk files, and (2) perform search and retrieval operations on their files, under a variety of search strategies. A more detailed discussion of these functions as performed by the Inquiry File program follows.

- (1) File generation and maintenance. Console Data Switch 0 requests the program to create a new file of inquiry records on the disk (destroying the existing file, if any). Use of this program function involves a file protection routine which is not shown in the flowchart. Console Data Switch 1 controls the addition of records to an existing disk file. This function is used to update the file each month by adding the coded records of all inquiries received by AFMDC during that month. Thus, the Inquiry File is no more than one month behind current inquiries.
- (2) Search and retrieval. Bypassing requests for file generation and maintenance functions transfers control to the search and retrieval section of the program. The operator is asked to specify the parameters on which a match between the search specification and disk file records is desired. Such a match must occur on all parameters which are specified as search parameters by the Console Data Switches if the record is to be printed on the search output. The inquiry program allows searches on any combination of the following parameters: machining operation, work material group, work material description, hardness, data analyst answering the inquiry, SIC code of the organization submitting the inquiry, AFMDC internal codes for the company, division and individual submitting the inquiry and the month and year during which the inquiry was processed. Through the search specification options provided by the program, one may request searches of various scopes by specifying more or fewer index parameters for a search to narrow or broaden the selection of file references. This concept is fundamental to all of the search and retrieval programs operated by AFMDC.

Output of Inquiry File Search (Figure 6, page 9)

The Inquiry File, which, as of July 31, 1969, contained data pertaining to 4,456 inquiries, is a very important AFMDC file. Search of this file can prevent duplication of effort in answering identical inquiries or provide assistance in responding to those which are similar to past inquiries. Additional information about the source of the inquiry, which is also stored in the disk file, is used to generate data for AFMDC's required Monthly and Annual Reports.

Figure 6, page 9, shows the use of Data Switches described in Figure 5, page 8, as they were utilized to make broad and then selective searches on the Inquiry File. The first search was made on the uniterm, CUT FLUID, by having Data Switch No. 5 in the 'on' position. When the file was interrogated the machine selected and printed all inquiries for which the uniterm, CUT FLUID, was used. To be more selective on the second search, material group 301 (NICKEL BASE HIGH TEMPERATURE ALLOYS) and material description INCOX750 were added to the CUT FLUID uniterm on the search card. In the third search, the machining operation requirement was added so that now the search was concentrated on a specific operation, on a specific material group, one specific material description and a uniterm requirement. From this type of search, the computer finds a precise match and prints that information. The number on the right is a unique number to that inquiry so the information may be reached quite rapidly.

Output of Uniterm File Search (Figure 7, page 10)

The uniterm concept was designed so that technical text important to material removal operations could be stored and retrieved. Each document is assigned uniterms (keywords) which describe the nature of the text. These uniterms are punched into cards which are stored on disks.

A second card is generated indicating the machining operations and material groups associated with the given uniterm. Thus, a selective search can be made linking a particular uniterm to a specific machining operation and/or a material group.

A master list of the uniterms is contained in the code book so that search strategies may be set up. A search can be made on a single term or on two terms simultaneously. These terms may be in any position within the card set. The search shown in Figure 7, page 10, is for the Uniterm, TOOL GEOMETRY (TOOL GEOM) for a given operation, DRILLING (085) of NICKEL BASE HIGH TEMPERATURE ALLOYS (material group 301). On the right hand side of the computer printout are the source control codes for the documents containing the desired information.

Output of Final Technical Evaluated Data (Figure 8, page 11)

Figure 8, page 11, is a computer printout of information which has been extracted from a document which received Final Technical Evaluation. Note that most of the information extracted by the Machining Data Analyst and coded on the forms in Figure 4, page 7, is now computer decoded and printed out. The lines below the heading are the retrieved Tool Material, Tool Geometry, Cutting Fluid and Numerical Data associated with the particular machining situation described in the Inquiry Card. The particular search made in this case was for machining data in turning of INC0718, a nickel base high temperature alloy.

Computer Printout of a Selective Search on Surface Integrity File (Figure 9, page 12)

One of the subjects of highest interest to AFMDC inquirers as indicated in Figure 19, page 23, is Surface Integrity. Because of the large number of documents in AFMDC's storage on this broad subject and the wide variety of parameters within this subject a special computer file was set up to facilitate searching on this subject. The computer program used on this file is basically the same as that used on the Uniterm File which is described on this page. Figure 9, page 12, is a computer printout of a search made on "Surf Integrity" as it pertains to machined surface in SURFACE GRINDING (160) of TITANIUM ALLOYS (321). In particular, the alteration to the machined surface that was requested in the search was RESIDUAL STRESS.

Formulae Used in Determining Cost Per Piece In
Face Milling and End Milling (Figure 10, page 13)
Cost and Production Rate For Milling (Figure 11, page 14)

The use of data shown in Figure 8, page 11, leaves something to be desired for the manufacturing engineer. The printout gives a series of values to choose from but does not clearly indicate the economics involved. Since the major reason for having adequate data is to help minimize the cost, the logical question is which set of values will yield the minimum cost. Basic equations have been developed for turning, milling, drilling, reaming and tapping which considers the economics of each significant element of a machining operation and determines the machining cost and production rate. The equations developed for calculating machining costs in face milling and end milling are shown in Figure 10, page 13. Equations and computer programs have also been developed for computing production rates. Available representative hard data processed using these computer programs provide output giving the cost and production rate and the value of elements which make up the total cost as shown in Figure 11, page 14. These values give the engineer an opportunity to analyze the elements so that he may decide where the major contributors to the total cost lie and then work on the critical areas.

Computer Printout for Investigating Relationships
between Machining Variables (Figure 12, page 15)

Experience has shown that there are some relationships in machining variables between the various types of machining operations and work materials, and they can be determined if careful analyses are made using substantial and reliable data. Manual analyses of this type are difficult and cumbersome. Determination of existing relationships will be very valuable for evaluation of new data and filling in gaps in accrued data. AFMDC is investigating these relationships. The computer resolves much of the difficulty and time required to make the subject analyses. The computer program has been made operational, and a considerable amount of reliable data is available in punched card form for processing. One of the initial sets of data run through the computer is shown in Figure 12, page 15.

The particular relationship being investigated in this case is the effect of hardness on cutting speed and feed. This effect is indicated in the column titled Percent Change - Speed and Feed. By plotting the calculated values it is possible to determine whether or not a mathematical equation can be derived that describes the relationship between the machining variables being investigated.

Inquiry Processing Flow Chart (Figure 13, page 16)
Typical Inquiry Input and Response (Figure 14, page 17)

Responses to inquiries are the most important of the services provided by AFMDC. Strong emphasis is placed on providing specific and detailed answers to technical inquiries which are transmitted by letter, telegram, telephone or by direct visitation to the Center. A high percentage of the inquiries is made via telephone, some because of the urgency of information requirements and others due to the necessity of discuss-

ing technical details with the engineering personnel. When required, inquirers are contacted to clarify their specific needs. As indicated in Figure 13, page 16, engineering personnel impose judgments on the inquiries and establish the search strategies. Data processing personnel perform the computer search functions and provide the printouts to the engineers. The engineers again impose engineering judgment in the selection and preparation of the information to be transmitted to the inquirer.

An inquiry form and the AFMDC response are shown in Figure 14, page 17. Note the codes within the blocks on the form which are keypunched and then stored on the computer Inquiry File.

Summary of Specific Inquiries by Type of Inquiry
(Figure 15, pages 18 and 19)

The statistics shown in Figure 15, pages 18 and 19, point out several important factors. There has been a constant and substantial rate of growth in the number of inquiries received and processed at AFMDC. The average was 69 per month during the first four-year period of the Center's operation. During the last 10-month period the average was 114 per month. This growth has largely been the result of multiple inquiries from prior users, new contacts from companies already on the Inquiry File and contacts from companies who have not previously submitted inquiries to AFMDC. Many of the new contacts can be attributed to "word of mouth" communication of AFMDC inquiries with persons who are in the field of machining.

Another factor responsible for this growth has been the AFMDC plant visitation program and participation in technical conferences.

In addition to providing information on the varied services available at AFMDC, Figure 15, pages 18 and 19, indicates trends in the nature of inquiries from October 1964 to the present. In particular, it has been noted that inquiries are becoming more specific and are concerned with more complex and difficult machining situations. The relative increase in inquiry types 2, 3, 15 and 16 bears out this conclusion.

The inquirer profile has also been relatively changing. A higher percentage of inquiries are being received at AFMDC from lower echelon personnel such as manufacturing or tool engineers, industrial engineers and time standards personnel, process engineers, tool designers, shop supervisors and foremen, planners, estimators, etc. This indicates that AFMDC is achieving its objective of reaching and setting up a direct line of communication with not only management, but also with an increasing number of persons directly responsible for application of machining data and information available from AFMDC.

Analysis of Inquiries by State (Figure 16, page 20)

The analysis of inquiries by state, Figure 16, page 20, provides some interesting and informative statistics. AFMDC has received inquiries from 44 states including the District of Columbia. Over the period October 1, 1964, through July 31, 1969, there have been 4,456 inquiries re-

ceived and processed by AFMDC. These inquiries have originated from 1,417 different organizations and 2,490 individuals within these organizations. It is interesting to note that over 75% of the total inquiries and over 77% of the company and individual inquiries were from 10 highly industrial states. The specific inquiry statistics for these 10 states are shown in Figure 16, page 20.

General Analysis of Inquiries and Analysis of Inquiries by Material Group (Figure 17, page 21)

The chart, General Analysis of Inquiries, provides perspective of the relative complexity of inquiries, processed during the past 3-1/2 years. Of the inquiries related to given machining operations and material groups, over 75% were concerned with more than a single machining situation (one operation on one material group) for the past 3-1/2 years period. Over one-third of the inquiries were of the unitem (keyword) type.

The Analysis of Inquiries by Material Group helps to provide AFMDC with perspective of user needs, input requirements, and establishes priority and extent of detailed technical evaluation of the input. An analysis of the past 3-1/2 years' inquiries was made categorizing the materials involved by 15 material groups. Figure 17, page 21, shows there has been a high level of interest for machining data on high temperature alloys, titanium alloys and refractory alloys. A high total of 1,734 requests was made for plain carbon, low alloy steels, ultra-high strength and tool steels covering the 3-1/2 years period. Information for stainless steels was in high demand as evidenced in the 839 requests. High interest has also been expressed in machining information for non metal-latics. A total of 388 inquiries has been processed on this subject.

Analysis of Inquiries by Type of Machining Operation (Figure 18, page 22)

Added perspective of User needs and in turn AFMDC input requirements are obtained by analyses such as shown in Figure 18, page 22. Approximately 12,000 requests for information on specific machining operations have been received during the past 3-1/2 years. For conventional chip removal types of operations the statistics indicate that emphasis on input and detailed evaluation should be on turning, face milling, end milling, drilling, reaming and tapping. For conventional grinding, the highest interest has been in surface and cylindrical grinding operations. The total of 791 requests for information on the alternate machining methods are indicative of the increasing interests in these machining methods and alert AFMDC to an important area of its Users' needs.

Analysis of Unitem Type Inquiries (Figure 19, page 23)

A high percentage of the inquiries received at AFMDC are of the unitem (keyword) type. This machining information is of the technical text type. The 17 subjects of highest interest for this type of machining information are shown in Figure 19, page 23. Very high interest has been expressed for information on surface integrity, numerical control, cutting fluids, surface finish, distortion and time standards.

Summary of Specific Inquiries by SIC Number (Figure 20, pages 24 and 25)

An analysis of inquiries by type of industry utilizing the services of AFMDC is shown in Figure 20, pages 24 and 25. The chart presents the inquiries by SIC Code, a number which references listings in the Standard Industrial Classification Manual, Executive Office of the President, Bureau of the Budget, 1967. While some SIC descriptions may appear completely commercial, an analysis of specific inquiries will indicate a close relationship to DoD requirements, as shown in Figure 21, page 26.

SIC Major Group No. 37, Transportation Equipment, is the predominant group with respect to utilizing AFMDC services. This group encompasses three significant industry users of AFMDC, namely: Aircraft and Missiles; Aircraft Engines and Engine Parts and Missile Engines; and Aircraft Parts and Auxiliary Equipment and Missile Parts. Other SIC Major Groups who provided relatively high quantities of inquiries to AFMDC during the past 10 months are: 91 - Federal Government; 33 - Primary Metal Industries; 34 - Fabricated Metal Products Except Ordnance, Machinery and Transportation Equipment; 35 - Machinery, Except Electrical; 36 - Electrical Machinery Equipment and Supplies; 73 - Miscellaneous Business Services; 82 - Educational Services.

Government Agencies and Services Supported Directly and Indirectly
by AFMDC Inquiries (Figure 21, page 26)

The data shown in this chart are somewhat difficult to compile but by careful analysis of particular inquiries and by an analysis of the prime objectives of principal contractors at various plant locations it has been possible to show that 1,081 of the 1,141 requests made to the Center were stimulated by Air Force, U.S. Navy, U.S. Army, AEC, NASA, STSP and SBA projects.

Summary of Inquiries Processed by AFMDC For STSP and SBA
(Figure 22, page 27)

AFMDC has taken the initiative in actively participating in the broad programs of information services being offered in the State Technical Services Program.

The following steps were taken by AFMDC to attempt to provide awareness of the Center's services to states having such programs:

1. Personal participation in conferences and meetings conducted by the states of Illinois, Indiana, Michigan and Vermont.
2. Meetings with key persons in the Office of the State Technical Services, Washington, D.C., for the purpose of keying in with the entire State Technical Service Program.

A direct result from these discussions was that AFMDC was chosen to participate in a Special Merit Project with the State of Vermont, along with another DoD Information Analysis Center; namely, PLASTEC.

The purpose of this Special Merit Program is to evaluate for one year, on an experimental basis, the feasibility of referring Vermont industry and business to Federal Information Analysis Centers for answers to their technical questions. During the month of November, seven Vermont cities were selected for one day conferences at which industry leaders were invited to attend. Between November 6th and 14th, presentations on AFMDC services by the Center's personnel were given in Rutland, Bennington, Montpelier and Burlington, Vermont, and on November 19th at Springfield.

3. During December 1968, AFMDC contacted directors or acting directors of approximately 35 State Technical Service Programs, which did not use the Center's services to that date. In addition to supplying each a copy of AFMDC's Fourth Annual Report, other descriptive material was submitted.

AFMDC has received and processed 113 inquiries from 19 different State Technical Services Programs. Between October 1, 1968 and July 31, 1969, forty one inquiries were provided by various STSP agencies, as shown in Figure 22, page 27.

The Small Business Administration Programs are concerned primarily with technology transfer to small business firms. Essentially the same approach and efforts made by AFMDC with respect to the State Technical Service Programs were made with the Small Business Administration Programs. In addition to making available the Center's inquiry services to these programs, AFMDC has directly participated in three technical conferences set up by SBA and has accepted invitations to participate in two such conferences scheduled for early fall 1969.

To date, AFMDC has received and processed 47 inquiries from 12 regional offices of SBA. Of these 47 inquiries, 40 were received during the last ten-month period as shown in Figure 22, page 27, indicating the increase participation of SBA with AFMDC.

Companies and Agencies Submitting Inquiries to AFMDC
(Figure 23, pages 28-39)

Summary of Specific Inquiries by Companies Making
Five or More Requests (Figure 24, pages 40 and 41)

Figure 23, pages 28-39, presents a total of 1,417 individual companies and divisions which have been inquirers of AFMDC, an increase of 279 organizations during the last 10-month period. These are listed on pages 37, 38 and 39 of Figure 23. This is a comprehensive list. Figure 24, pages 40 and 41, includes a summary of the 455 organizations (includes the divisions of each organization listed) making five or more requests. This group has provided 3,049 of the 4,456 inquiries processed by AFMDC to date. This represents over two thirds of all inquiries submitted to AFMDC. The multiple requests for machining information from the listed 455 organizations are considered to be a good criteria for the value placed on AFMDC's services. This list reflects high interest in AFMDC

information on the part of aerospace industry, as represented by companies such as Aerojet-General Corporation, The Boeing Company, Curtiss-Wright Corporation, General Dynamics Corporation, General Electric Company, Goodyear Aerospace Corporation, Grumman Aircraft Engineering Corporation, Hughes Aircraft Company, Lockheed Aircraft Corporation, Martin Company, McDonnell Douglas Corporation, North American Rockwell Corporation, Pratt and Whitney Aircraft, TRW Inc., Tinker Air Force Base and in fact Wright-Patterson Air Force Base itself.

Photograph of AFMDC Data Products (Figure 25, page 42)

Photograph of AFMDC Titanium Booklet (Figure 26, page 43)

Typical Formats for Data Presentation (Figure 27, page 44)

Planned data products have proven to be important output to AFMDC Users. In addition to providing valuable and timely data, these products serve as a direct line of communication with the Users of the Center. Excellent response has been received to the 13 data products prepared and issued to date. Some of these products are shown in the photo in Figure 25, page 42, and the formats are displayed in Figures 26 and 27, pages 43 and 44. Careful thought was given to the preparations of the products to present the machining recommendations in complete but concise form in order to make easy and effective use of them.

Over 1,500 recommendations for different machining situations are contained in the data products prepared to date. These recommendations offer great potential for vast machining savings by industry. It has been very conservatively estimated that the 17,833 copies of the data products distributed through July 31, 1969, have resulted in an estimated saving of 26,749,500.00 dollars. More detailed discussion of all the estimated savings resulting from AFMDC's services is provided in a later portion of this report.

Description and Distribution of AFMDC Data Products (Figure 28, page 45)

There were two primary means used for publicizing the data products. AFMDC prepared three separate data product announcements and sent them to the User File which now consists of 5,315 individual names. A second means used for reaching persons who would have an interest in the data products was accomplished by sending copies of these documents to about 60 editors of technical periodicals. Each of these were encouraged to publish announcements of the products and print typical data sheets. This not only stimulated interest in the data products, but also in the Center's services in general. Numerous inquiries were submitted to the Center each time a periodical published the information provided by AFMDC.

The fine response for data products is indicated in Figure 28, page 45. A total of 17,833 copies were distributed, most of which were to the User File and some as direct response to inquiries.

Data Acquisition Plant Visit Program (page 46)

To date AFMDC personnel have visited 56 plants for the purpose of acquiring machining data from them on a regular basis. Emphasis was placed on visiting aerospace firms. Visits to all plants were satisfactory and there was general interest in this project. Many of the plants have taken steps to make necessary arrangements for transmitting data. Over 400 reports of high data yield have already been received from these plants. Follow-up is being made in the form of correspondence and periodic visits.

During all visits detailed information was provided concerning AFMDC's organization and how it functions. Effort was made to reach directly or through responsible supervisory personnel the lower echelon manufacturing and manufacturing engineering people who need data for immediate application to machining of hardware. The effect of this approach was noted in the significant increase in inquiries received from most of the companies visited.

Code Sheet for Project Time Card (Figure 29, pages 47 and 48)

AFMDC Daily Time Slip (Figure 30, page 49)

Computer Printout of AFMDC Project Time Cards (Figure 31, page 50)

The code sheet provides the basic approach to AFMDC System Costing. Approximately 100 individual time codes are in current use. It has been simple for individuals to maintain time records because relatively few time codes are used by any one person during a given day and the use of the same codes is repeated from day to day. Figure 30, page 49, shows a Daily Time Slip which indicates the manner in which individuals record their time.

The information from these time slips is punched into cards and the information is stored in the IBM 1130 computer. Figure 31, page 50, is a computer printout of AFMDC project time cards.

Figures 32 and 33, shown on pages 51, 52 and 53, reflect the use made of project time card data. These records are available for making even more detailed analyses when required. For example, it would be possible to analyze the cost for a particular project, such as a special report requested by DoD.

AFMDC Operating Costs (Figure 32, page 51)

AFMDC Input and Output Summary (Figures 33, pages 52 and 53)

Figure 32, page 51, shows the operating costs for the past ten months broken down into five major groups: 1) Input, 2) Output, 3) General Dissemination, 4) Reports and 5) Systems Analysis, Modification and Control. A summary of these costs follows:

Summary of AFMDC Operating Costs
October 1, 1968 - July 31, 1969

Major Group	Cost	% of Total Cost
Input	91,562.24	40.9
Output	88,733.59	39.6
General Dissemination	5,693.64	2.5
Reports	21,036.57	9.4
Systems Analysis, Modification and Control	16,933.90	7.6
Total Operating Costs	\$223,959.94	

It is significant to note that the output costs represent 39.6% of the total operating costs. This is considered to be a relatively high figure for an information analysis center.

The chart in Figure 33, pages 52 and 53, presents various summaries of AFMDC input and output. As of July 31, 1969, there were 19,721 evaluated documents in AFMDC's storage. The important information from these documents has been extracted, coded and punched into 149,951 cards and stored on the IBM 1130 Computer. Unit costs for processing of inquiries are cited in Figure 33, pages 52 and 53. It can be noted that the average cost for processing an inquiry has remained relatively stable over the 4-3/4 years' operation of AFMDC despite the increasing complexity of inquiries. The growth in engineering and data processing experience as well as the number of documents in AFMDC storage are the main reasons for being able to handle more complex inquiries without significant change in average cost.

Economic Environment For AFMDC Operations (Figure 34, page 54)

The importance of the machining industry on our economy is clearly illustrated by the fact that the total costs of labor and overhead alone for chip removal in the U.S. is 40 billion dollars annually. This conservative estimate is based on the total of approximately 2,500,000 metal cutting machine tools in active use, 8 hours per day, 5 days per week and an average of labor cost + overhead of \$8.00 per hour. Further perspective of the magnitude of importance of this industry is gained by reviewing other statistics. An article titled, "69 Outlook, Part 1, Economic", published in the American Machinist, January 27, 1969, reports that metalworking manufacturers shipped about 246 billion dollars worth of goods in 1968, which represented 28.6% of the Gross National Product. Machining, naturally, is a very important segment of the metalworking field. The same article cites statistics on research and de-

velopment spending. Quoting this article, "In 1968, research and development expenditures by metalworking manufacturers topped 14 billion dollars, accounting for nearly 80% of the total spent by all industry for R & D".

Potential for AFMDC Services to Industry (Figure 35, page 55)

The statistics shown in Figure 35, page 55, indicate that five major SIC Groups provide a vast potential for utilization of AFMDC services and they have been the primary groups submitting inquiries to AFMDC. The left-hand side of the chart, Figure 35, page 55, provides a statistical summary of metalworking plants consisting of a partial SIC list taken from Dun and Bradstreet Metalworking Directory, 1967-68. The right-hand side of the chart summarizes AFMDC inquiries for the same SIC classifications.

As would be expected, the largest number of inquiries have been received from Major Group 37, Transportation Equipment. Four of the SIC Industrial Classifications within this group are: 3721 - Aircraft and Missiles; 3722 - Aircraft Engines and Parts; 3723 - Aircraft Propellers and Propeller Parts; and 3729 - Aircraft Parts and Auxiliary Equipment. A second significant source of inquiries is Major Group 35, Machinery Except Electrical. Some of the important industries included in this group are Machine Tools-Metal Cutting Types, Machine Tool Accessories and Measuring Devices and Machine Shops - Jobbing and Repairing. The statistics from Dun and Bradstreet's Metalworking Directory display a vast economic environment for AFMDC operations. Metalworking is the prime activity for five major groups alone, comprised of 29,431 companies (20 or more employees), employing 6,900,557 individuals. There are 20,063 other companies (20 or more employees), for which metalworking is a secondary activity. Dun and Bradstreet reports that 21,364 of the 38,383 listings in its Metalworking Directory perform machining operations. Although no specific statistics can be quoted, there is no doubt that there is even a larger number of firms (employing less than 20 individuals), whose major activity is machining. Considering that to date there has been a total of 1,417 organizations which have submitted inquiries to AFMDC speaks for itself regarding the potential increase in services that is possible to the machining industry.

Cost Savings Resulting From AFMDC Operation (Figure 36, page 56)

The base used for estimating cost savings resulting from AFMDC's operation is a machining situation which is defined as a specific material removal operation being used on a specific material with definite chemical, physical or mechanical properties. There are many specific parameters that make a machining situation complex. The parameters include: machining operation, work material and its metallurgical and physical characteristics such as, microstructure, hardness, strength, modulus of the elasticity, etc., the part configuration, dimensional and surface finish tolerances, the machine tool being utilized, tool material, tool geometry, cutting fluid, cutting speed, feed and tool life.

This inherent complexity of a machining situation naturally reflects itself in a high cost required to develop the proper combination of parameters needed to effectively perform a given machining operation.

Several members of the AFMDC staff have had direct and extensive experience in the development and application of machining data, particularly in aerospace plants. A major part of the experience has been in increasing productivity of existing machining operations, establishing effective machining parameters for new production operations and solving problems being encountered on critical operations.

It has been the experience of the staff members of AFMDC that the selection of the proper combination of machining parameters can result in major cost savings. The most common method practiced in arriving at a workable set of conditions is that of "hit or miss". This is a costly method and manifests itself in high expenditure of time, broken cutting tools, costly scrapped parts and schedule delays. One alternative is the systematic generation of the required machinability data in a machinability laboratory or on a production machine. This method is effective but also time consuming and costly. Ofttimes, production schedules do not permit the required time.

The consensus of these AFMDC staff members is that the dollar value of a set of recommended parameters for one machining situation given in response to an inquiry is very conservatively \$800.00, and usually runs into thousands of dollars. Thus, the \$800.00 value assigned in the cost analysis for a set of evaluated parameters applicable to a specific machining situation is indeed ultra conservative. This is particularly true in the case of a specific inquiry for which there is almost invariably an immediate need for reliable data.

For the purposes of this report a value of \$300.00 was assigned for the cost saving resulting from the application of one set of data utilized from an AFMDC data product. Each data product issued from the Center was in response to an AFMDC data product announcement, or was sold. A relative few were used in response to an inquiry in those cases where the data product was directly applicable. It is reasonable to assume that each individual who received an AFMDC data product had a need for some portion of the published data. Each of the data products contain hundreds, and in some cases thousands, of recommendations for machining situations. In the cost analysis presented in this report it has been assumed that only the one individual who received the data product used it. Further, it was assumed that he applied only five machining situations from the product. These assumptions are most conservative.

Very conservatively it has been estimated that a total of \$45,093,500.00 cost savings to AFMDC Users has resulted from the operation in 4-3/4 years. These savings are attributed to the Center's response to specific inquiries and its data products. Figure 36, page 56, presents the pertinent statistics used to make the aforementioned estimated cost savings. Considering the total funds made available to AFMDC during this 4-3/4 year period, for each dollar expended there was a return of ap-

proximately \$45.00 in effected cost savings. If the services provided by AFMDC were not available, the cost to the Government and industry would by far exceed the \$45,093,500.00 figure. This conclusion was substantiated by examples provided by industry of the value of the Centers' services and cited in an AFMDC report, "Cost Savings Resulting From The Operation Of The Air Force Machinability Data Center", July 29, 1968.

Considerable value must also be placed on what timely and reliable machining information has on eliminating or minimizing production delays. It is not possible to assess dollar values for such cases, but significant emphasis should be placed on the impact of production delays. Another value of reliable machining data that is extremely difficult to place in terms of dollars is its importance on the quality and integrity of machined parts. The majority of companies involved in machining do not have proper facilities or capability to develop good reliable machining data. Those that generate this data do so at a very high cost, very often at the expense of the Government.

AFMDC Plans For Recovery of Output Costs (Figure 37, page 57)

In July 1968, Mr. John S. Foster, Jr., Director of the Defense Research and Engineering, Department of Defense, issued a memorandum titled, "Plans for Charges at Information Analysis Centers". Mr. Foster requested a plan whereby all output costs encountered by AFMDC be recovered by an orderly transition to a schedule of charging for services provided by the Center. Such a plan has been developed.

The three services provided by AFMDC that are considered output are:

1. Answers To Specific Inquiries
2. Data Products
3. Special Seminars

The most significant area of the three with respect to cost is answering of specific inquiries. Therefore, the major effort made in developing a plan was devoted to this aspect of AFMDC output. An analysis was made of a cross section of AFMDC inquirers and the estimated cost savings associated with the inquiry services to them (see Figure 37, page 57). The analyses of inquiries consisted of identifying the number of machining situations involved and assigning a cost saving of \$800.00 per machining situation. The proposed inquiry charges were then calculated, using as a base the saving of \$50.00 for each one dollar invested. Using the inquiry analyses as a base, fourteen major company users were contacted relative to their reaction to subscription fees for AFMDC inquiry services. Based on these contacts and the Center's judgements, the plan for recovery of inquiry output costs was prepared.

To simplify the paper work involved in charging for inquiries against an annual subscription fee, AFMDC will categorize inquiries by the following five types:

1. Information on several operations on several material groups.
2. General machining concepts (uniterm type) inquiries, such as information on cutting fluids, surface integrity, safety practices, tool material properties, etc.
3. Information pertaining to new machining processes, machinability research, setting time standards and production rates in machining.
4. Recommendations for a specific machining situation and comparison of one material or process with another.
5. Requests for specific documents, reports, books, papers, abstracts, bibliographies, evaluations or translations of reports, books or papers.

Different charges will be made for each category of inquiry depending on its complexity.

Potential subscribers to AFMDC inquiry services will be given detailed information on services that have been provided to them. This will include synopsis of inquiries, the persons who received the inquiry responses and the estimated cost savings associated with the inquiries. Thus, management can use this information to evaluate the impact that AFMDC services had in the solution of machining problems and the resultant cost savings.

The Center will continue to prepare timely and useful data products. It is planned that charges for these data products will be such that they will offset the cost of their preparation and printing. A very important data product that will become available to the machining industry September 1970 is a revision of the Machining Data Handbook. Considerable additions and revisions will be made to the current edition of the handbook.

AFMDC plans to periodically conduct special seminars on subjects of high interest. Costs involved with these seminars consist of preparation of technical material, time spent at seminars, travel cost and cost for published material to be disseminated at the seminar. To recover these costs attendees will be charged the appropriate fees.

Future Planning (page 58)

It is planned that a revised Machining Data Handbook will be published in September 1970. The current edition contains 605 pages of which 410 are concerned with machining recommendations. The balance of the book

consists of various other useful machining information. The revision will not only update the existing machining data and information, but will also have major additions. It will require considerable effort to perform this task.

AFMDC, as well as other DoD funded Information Analysis Centers were requested to plan for recovery of output costs. A broad plan was developed, but considerable detailed work must be accomplished prior to the time when inquiry service charges are instituted. This work involves preparation of cost savings analyses related to inquiry responses to the important AFMDC Users. These analyses and related information are necessary for the management of potential subscribers to AFMDC in order to make cost decisions.

An orderly transition to a schedule of charging for inquiry services will begin during the first half of calendar year 1970.

Preparation of data products is a major output of the Center and requires substantial effort and cost. Recovery of cost is entirely dependent on the sale of these data products. For the next data product to be completed, namely, the Revision of the Machining Data Handbook, it will be necessary to have a high volume of sales of this book in order to recover costs incurred in its preparation and publication. It is planned to generate high sales volume by sending announcements to the approximately 5000 persons in the Center's User File, by use of mailing lists obtained from various sources listing organizations in the machining field and by effecting announcements in technical journals of the availability and content of the handbook.

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)		2a. REPORT SECURITY CLASSIFICATION Unclassified
Metcut Research Associates Inc. Cincinnati, Ohio 45209		2b. GROUP N/A
3. REPORT TITLE Fifth Annual Report of the Air Force Machinability Data Center		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Report covering period October 1, 1968 thru July 31, 1969		
5. AUTHOR(S) (First name, middle initial, last name) Maranchik, Jr., John		
6. REPORT DATE October 1969		7a. TOTAL NO. OF PAGES 88
7b. NO. OF REFS 5 (See Preface)		
8a. CONTRACT OR GRANT NO. Contract F33615-69-C-1112		9a. ORIGINATOR'S REPORT NUMBER(S) AFMDC 69-6
b. PROJECT NO. 9M 810/8975		c.
d.		9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
10. DISTRIBUTION STATEMENT This document has been approved for public release and sale; its distribution is unlimited.		
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY Air Force Materials Laboratory Materials Support Division Wright-Patterson Air Force Base, Ohio
13. ABSTRACT This is the Fifth Annual Report of the Air Force Machinability Data Center covering period October 1, 1968 through July 31, 1969 (Contract F33615-69-C-1112). Three thousand and seven hundred and eighty (3,780) documents were processed from which 33,868 cards were key punched. Currently, there are 19,721 evaluated documents and 149,951 punched cards in AFMDC files. One thousand and one hundred and forty one (1,141) specific inquiries were answered for 520 different organizations, representing 753 individuals in 106 different SIC categories in this 10-month period. The average number of inquiries was 114 per month. Since the Center's operation began in October 1964 a total of 4,456 specific inquiries have been processed. Statistics are presented on cost savings by AFMDC Users. Through July 31, 1969 it has been estimated, very conservatively, that these savings amount to \$45,093,500.00. A summary is presented of AFMDC's proposed output recovery cost plans. Work continued on investigating relationships between machining variables and work materials. This abstract has been approved for public release and sale; its distribution is unlimited.		

DD FORM 1 NOV 68 1473

Unclassified
Security Classification

Unclassified

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Information Center						
Machining						
Management						
Data Center						
Information Center Costs						
Information Center Economics						
Computer Data Processing						
Data Products						

Unclassified

Security Classification